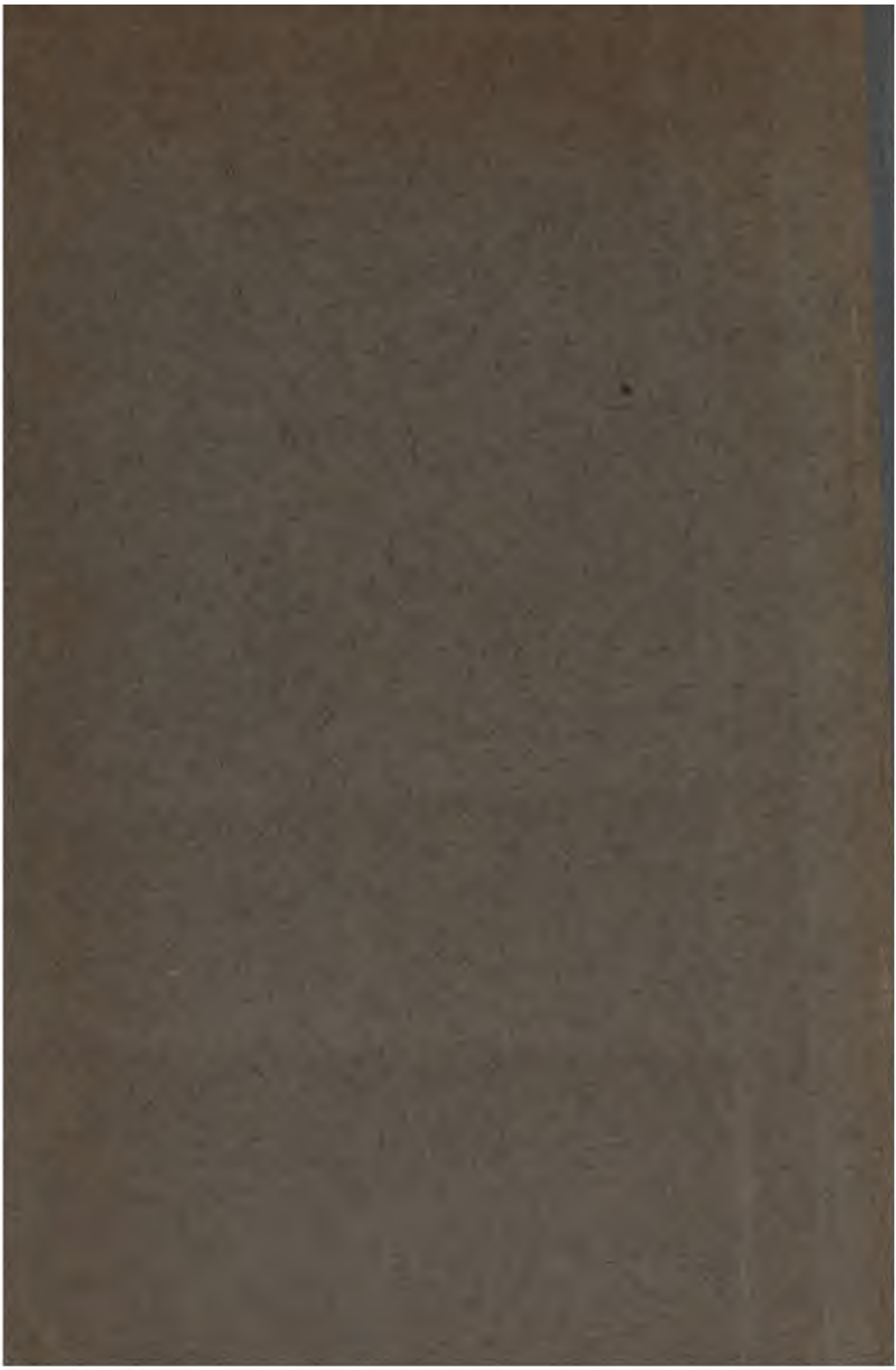
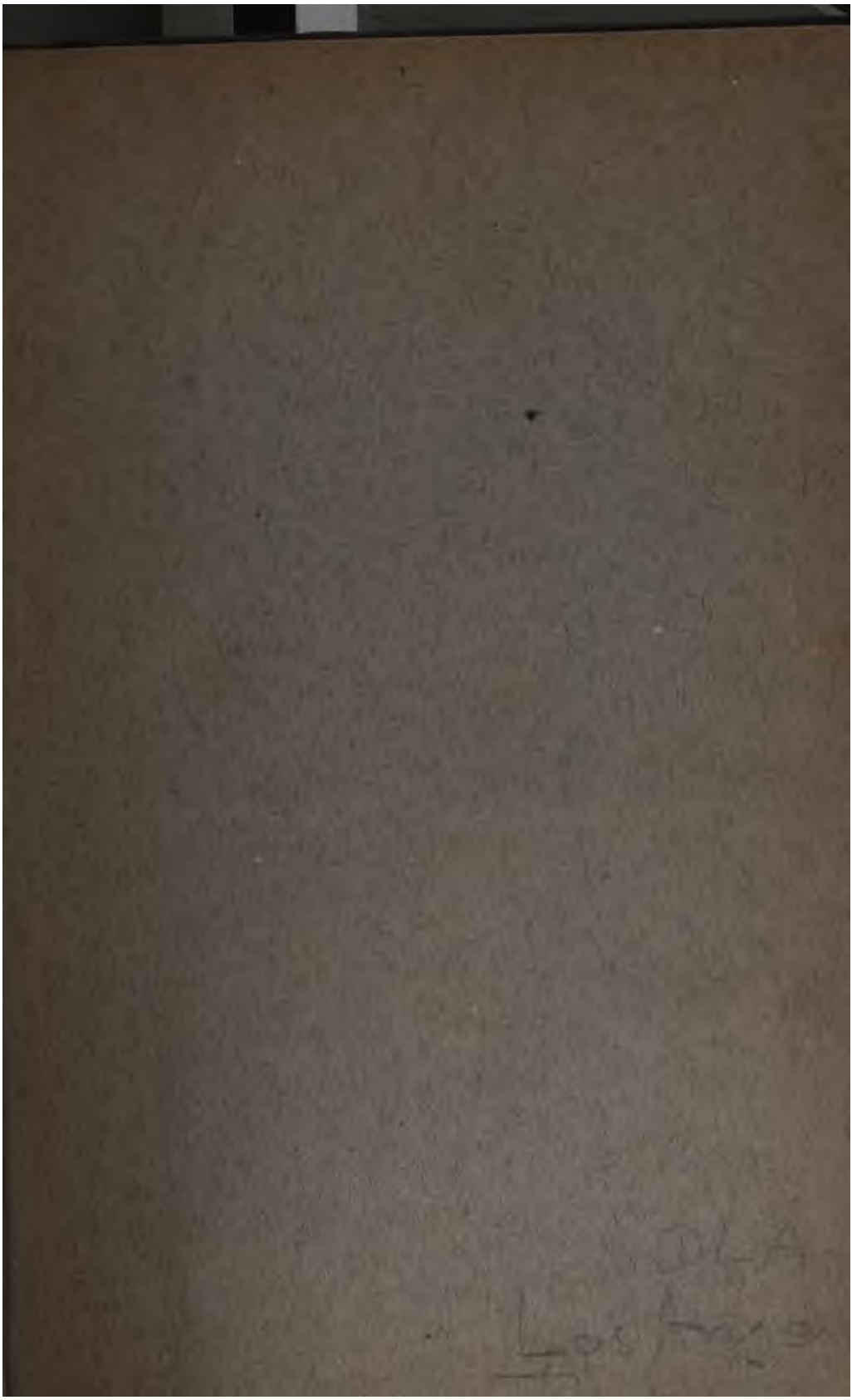
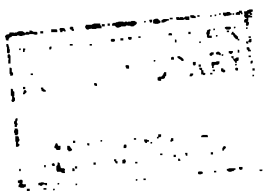






CITY OF LOS ANGELES

DEPARTMENT OF PUBLIC WORKS

LOS ANGELES, AQUEDUCT Bureau.

FIRST ANNUAL REPORT

—OF THE—

CHIEF ENGINEER OF THE LOS ANGELES AQUEDUCT TO THE BOARD OF PUBLIC WORKS,

March 15th, 1907

BOARD OF PUBLIC WORKS:

JAMES A. ANDERSON, President
ALBERT A. HUBBARD
DAVID K. EDWARDS

LOS ANGELES, CALIFORNIA
1907

CONTENTS

APPENDICES.

FIRST ANNUAL REPORT

—OF—

THE CHIEF ENGINEER OF THE LOS ANGELES AQUEDUCT TO THE BOARD OF PUBLIC WORKS.

EARLY HISTORY OF THE LOS ANGELES WATER WORKS.

The Pueblo of Los Angeles, upon its establishment in 1781, was invested by the laws of Spain with the right to take and use the waters of the stream flowing across its boundaries, now known as the Los Angeles River, for all public and domestic purposes. This right descended to its successor, the City of Los Angeles, and is the most valuable asset of the municipality.

In 1868, the city made a lease of its water-works to certain individuals, for the period of thirty years, together with the right to divert water from the Los Angeles River and distribute the same, at prescribed rates, to the inhabitants of the city. This lease was soon afterwards transferred to the Los Angeles City Water Company, a corporation formed especially for the purpose of constructing and operating the water works. It was provided in the lease that, at the end of the term of thirty years, the city should be entitled to the possession of the works upon paying the lessees, or their assigns, the value of the improvements. While the lease expired in 1898, the actual transfer of the possession and control of the property to the city was not consummated until February, 1902, the long delay being due to a controversy between the city and the water company, involving much litigation, over the amount to be paid on account of the improvements.

The management of the water works by the City, through its Board of Water Commissioners, has been marked by great efficiency and success, due, in large measure, to the fact that only men of recog-

nized ability and fitness have been selected as members of the board, and that the organization of the Water Department has been kept entirely free from politics and subject to civil service rules.

Under municipal management, the water rates have been substantially lower than those previously charged by the water company, amounting at present to about ten cents per thousand gallons, with a minimum monthly rate of 75 cents. This compares favorably with the rate of 24 cents per thousand gallons charged in San Francisco, 40 cents in Oakland, 30 cents in Alameda, and 35 cents in Berkeley.

For the year ending November 30, 1906, the gross income from the plant was $968,104.34, operating and maintenance charges amounted to $164,083.86, and the interest and sinking fund on bonds, issued for the purpose of purchasing the water works and making improvements, was $151,603.75, thus leaving a net revenue of $652,-416.73, and practically the whole of this amount was expended for extensions and improvements. During the past year, 246,500 feet, or 46.68 miles, of pipe mains were laid, none of which were less than four inches in diameter; 6978 meters were installed, bringing the percentage of taps metered up to 31 per cent; 5984 new connections were made, representing an addition of over 25,000 customers for the year; the Ivanhoe Reservoir, with a capacity of 50,000,000 gallons, was constructed, and the Pollock land was purchased and a pumping plant erected thereon.

Since taking possession of the water works in 1902, the Water Department has practically rebuilt the entire system, besides keeping pace, by extensions and improvements, with the extraordinary growth of the city; and the expenditures for all these purposes have been met out of the income from water rates.

NEED OF ADDITIONAL WATER SUPPLY.

The municipality, having fully demonstrated its ability to successfully operate and manage the domestic water works, has undertaken the solution of the more serious problem of providing an additional water supply, made necessary by the extraordinary growth of the city. As was stated in the report of the Board of Water Commissioners for the year ending November 30, 1904, in reference to the Los Angeles River, upon which the city depends almost exclusively for water, "the time has come when we shall have to supplement its flow from some other source."

In 1890, the population as shown by the federal census was 50,395. By 1900, it had doubled. In the next five years, it doubled again, and at the present time it probably exceeds 250,000.

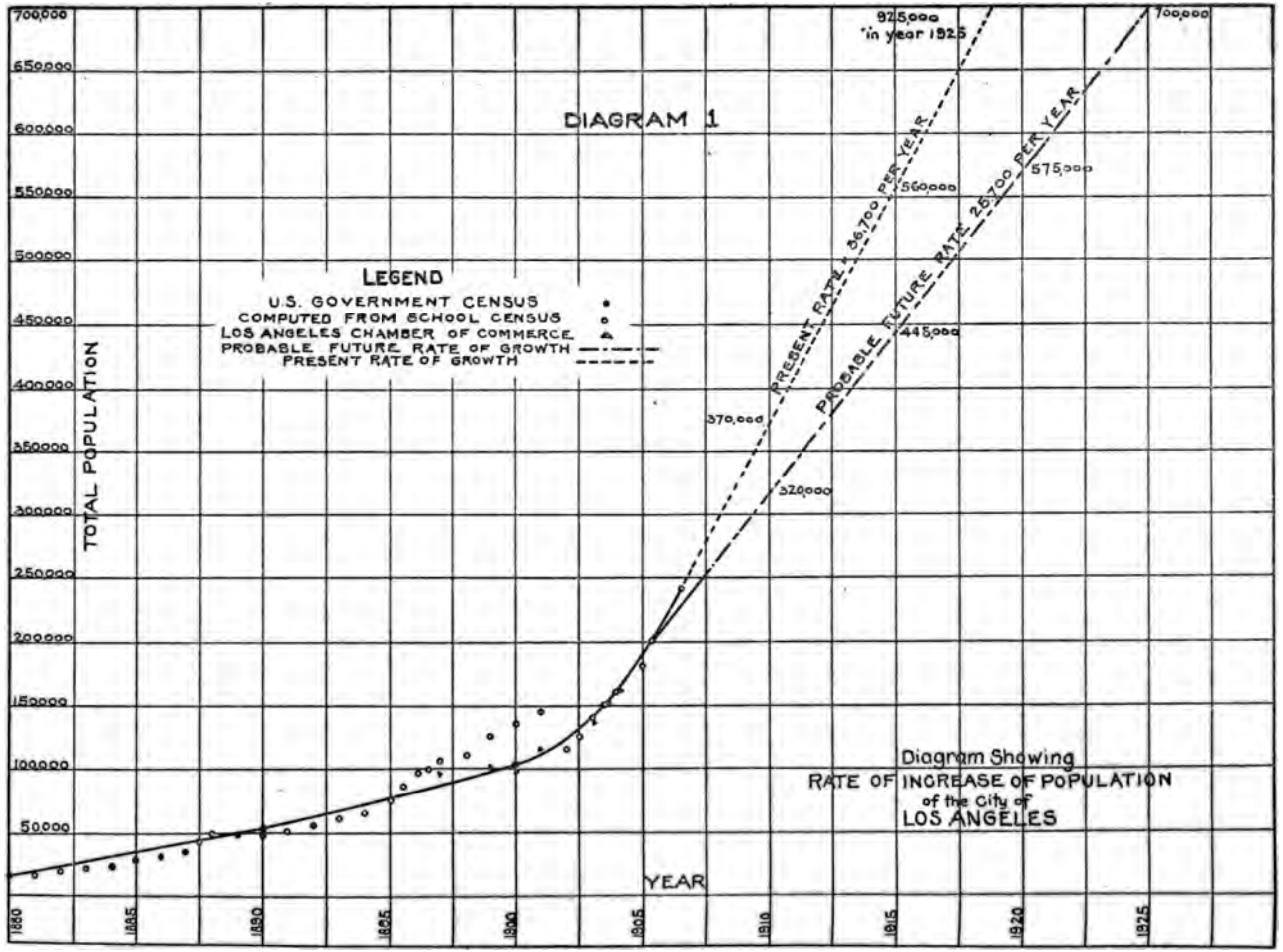


DIAGRAM 1
LEGEND
U.S. GOVERNMENT CENSUS
COMPUTED FROM SCHOOL CENSUS
LOS ANGELES CHAMBER OF COMMERCE
PROBABLE FUTURE RATE OF GROWTH
PRESENT RATE OF GROWTH
TOTAL POPULATION
YEAR
925,000 in year 1925
700,000
575,000
560,000
445,000
370,000
320,000
PRESENT RATE 36,700 PER YEAR
PROBABLE FUTURE RATE 25,700 PER YEAR
Diagram Showing
RATE OF INCREASE OF POPULATION
of the City of
LOS ANGELES

For the purpose of making an estimate of the future growth of Los Angeles, Diagram No. 1 has been compiled, the horizontal scale representing the years, and the vertical scale showing the population. On this diagram the city's population from the year 1880 is represented in three ways: (1) by the United States census; (2) by the estimate of the Los Angeles Chamber of Commerce, and (3) by an estimate based on the city's school census. It is found that the city had quite a uniform growth between the years 1880 and 1900. Since the latter date it has been more rapid, the population being now about 252,000. Projecting the average rate of growth for the years 1895 to 1907, inclusive, into the future, we find that Los Angeles should have a population of 445,000 in 1915; 575,000 in 1920, and 700,000 in 1925.

The following extract from the Fourth Annual Report of the Superintendent of the Water Department shows the available supply for the City, and the withdrawals for domestic consumption during the summer of 1905. "Summarizing the present sources of water supply, both temporary and permanent, for the inhabitants of the City of Los Angeles, they are at this writing (July 1, 1905) as follows:

	Sec. Ft.
The surface flow of the Los Angeles River	46
The sub-surface flow extracted from the tunnel under the Narrows above the Buena Vista Pump Station	9
A temporary supply obtained from the Jefferson Street plant of the West Los Angeles Water Company, under a contract which expires in June, 1907	1.5
The product of the wells at Slauson Avenue Pumping Plant	7
The product of a pumping plant located in the river bed opposite Los Feliz Point	8
Total	71.5

Expressed in gallons, this is equivalent to about forty-six millions daily.

There are now in use in the City of Los Angeles 15,810 meters, or 31 per cent. of all taps. The effect of the use of meters is indicated by the fact that the average summer consumption in 1906 was but thirty-six million gallons per day, as against thirty-four million gallons per day for the summer of 1905, in spite of the fact that 6,978 taps were added to the system during that year, the per capita consumption during the last year being 144 gallons. This is a very reasonable water consumption for a city of this size in a semi-arid country, particularly where gardening is so generally practiced, and we cannot hope to very

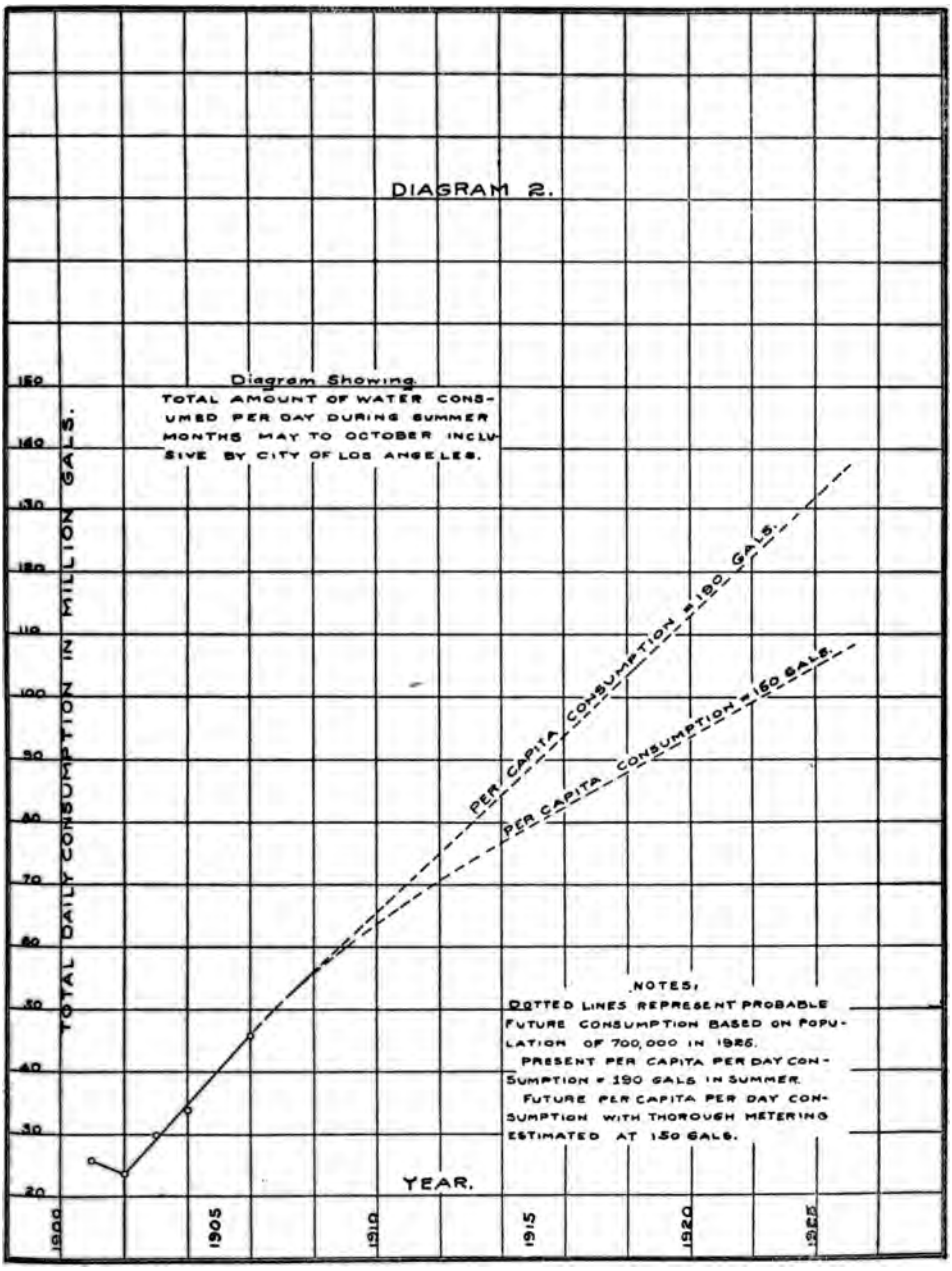


DIAGRAM 2.
Diagram Showing
TOTAL AMOUNT OF WATER CONSUMED PER DAY DURING SUMMER MONTHS MAY TO OCTOBER INCLUSIVE BY CITY OF LOS ANGELES.
TOTAL DAILY CONSUMPTION IN MILLION GALS.
150
140
130
120
110
100
90
80
70
60
50
40
30
20
PER CAPITA CONSUMPTION = 190 GALS.
PER CAPITA CONSUMPTION = 150 GALS.
NOTES:
DOTTED LINES REPRESENT PROBABLE FUTURE CONSUMPTION BASED ON POPULATION OF 700,000 IN 1925.
PRESENT PER CAPITA PER DAY CONSUMPTION = 190 GALS IN SUMMER.
FUTURE PER CAPITA PER DAY CONSUMPTION WITH THOROUGH METERING ESTIMATED AT 150 GALS.
YEAR.
1900
1905
1910
1915
1920
1925

greatly reduce this rate of consumption, as the more extravagant users of water in the city now have practically all been metered.

The water obtained locally has so far sufficed to maintain a supply equal to the needs of the city, but the following data from the Annual Report of the Water Department for 1904, shows the urgency for action in the procurement of an additional supply: Taking the ten-day period beginning July 20, 1904, on the morning of which the reservoirs were all full. "During this period the average daily rate of flow into the reservoirs was maintained as follows:

	Gallons.
From the River	27,255,000
From the Jefferson Street Plant	1,098,000
From the Narrows Gallery	4,199,000
From the Burbank Gallery and Pump	2,584,000
From the Los Feliz Point Pump	646,000
Total	35,782,000

It was found that up to July 30 the reservoirs had lost an average of 3,494,000 gallons per day, which shows that the consumption for the ten days averaged 39,276,000 gallons daily, and that in the meantime the reservoirs had been half emptied. Fortunately at this time the temperature moderated and the warning of the Department began to have its effect to such extent that the consumption dropped to about 33,000,000 gallons daily, thus enabling us to fill the reservoirs again."

The average rainfall at Los Angeles is 15.65 inches. The rainfall for 1904-1905 was 19.35; for 1905-1906, 18.70, and for 1906-1907, up to March 11, it is 17.26 inches.

The flow of the Los Angeles River for 1906 was 45.53 cubic feet per second, which is fully one-third less than was considered a mean flow of the river prior to the time when pumping began in the San Fernando Valley. These measurements indicate that we cannot rely on much relief from an increased water supply from the Los Angeles River, even if we have years of abundant rainfall. The water supply has been supplemented by pumping plants, but they should be considered more in the nature of a temporary relief than of a permanent benefit.

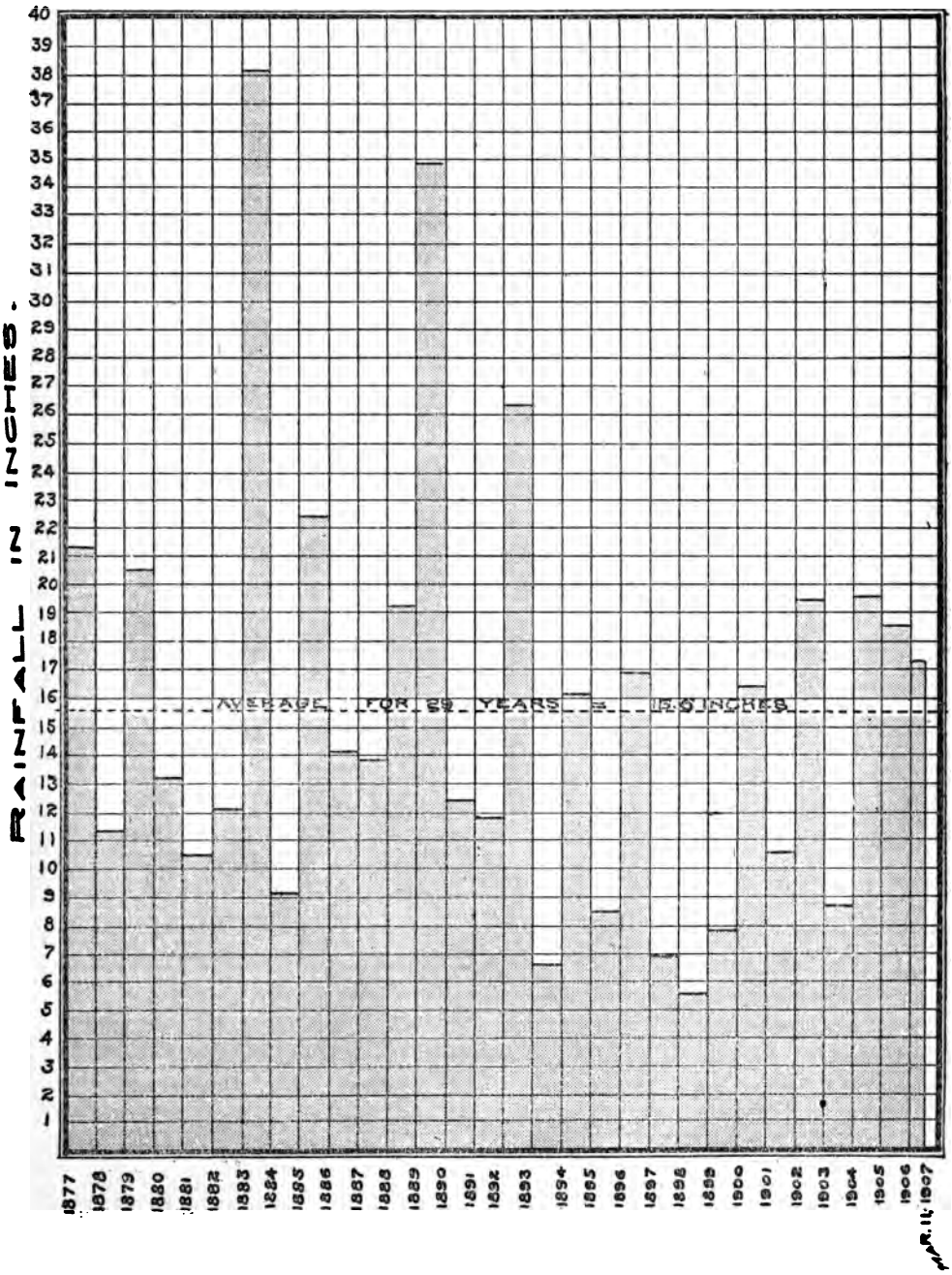
The Board of Water Commissioners very soon after taking up the consideration of the question of providing additional water for the city, had its attention directed to the Owens River Valley as a source of supply. But the Board felt that it should not favor or recommend a plan for going such a great distance for water, unless it should be found,

Diagram Showing

ANNUAL RAINFALL AT LOS ANGELES

For

Year's 1877 to 1907.



MAR. 11, 1907

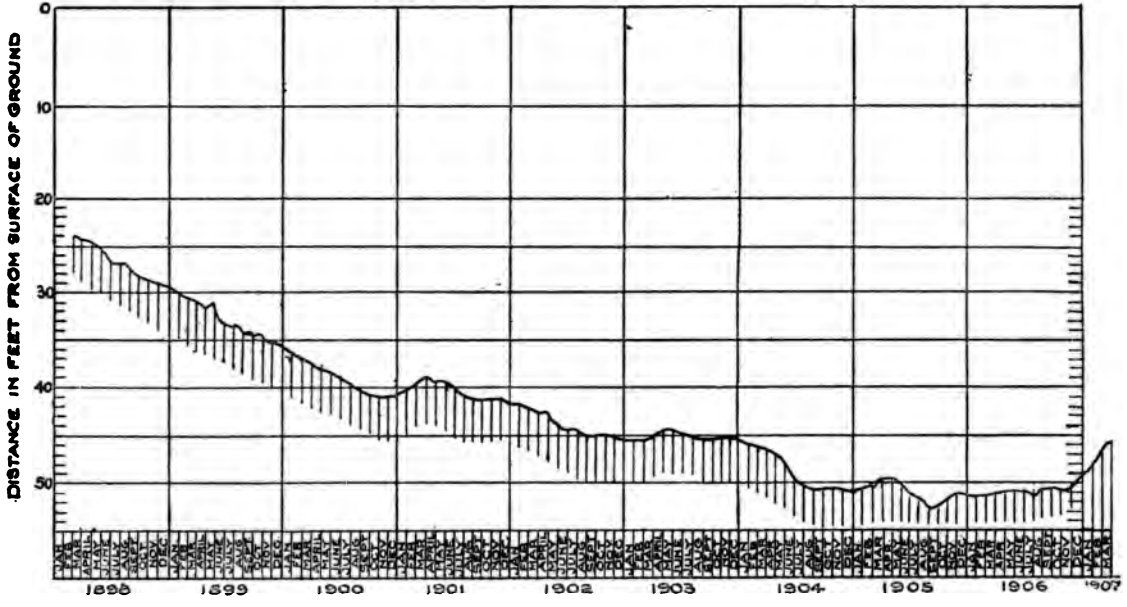
after thorough investigation, that no availage source of supply of the volume required could be obtained in Southern California. They, therefore, instructed their Superintendent and Engineer, in co-operation with Mr. J. B. Lippincott, who for the ten preceding years had been in charge of the investigation of the available water supply of California for the United States Geological Survey, to prepare a report on all available sources of water supply in Southern California. This report, containing seventy pages of printed matter, with illustrations, was issued as a public document, being a portion of the Fourth Annual Report of the Water Commissioners for the year ending November 30, 1905. In this investigation, particular attention was given to the underground waters in the gravel beds south of this city. In the preparation of the data for this report very material assistance was rendered by Mr. W. C. Mendenhall, Geologist of the United States Geological Survey, who for the past four years has been detailed to this study.

Mr. Mendenhall is the authority for the following statements relative to the underground waters southerly from the City: "In 1898 there were 375 square miles of valley area south of the Sierra Madre Mountains, from which artesian waters could be obtained. In six years this area had decreased 33½ per cent., and there had been a marked lowering of the water level in other wells. Within the area itself there had been a decrease in the discharge of artesian wells. The Bouton Well in 1899 flowed four million gallons daily. On May 13, 1903, this was flowing but 823,000 gallons daily—a decrease of 80 per cent. The falling off of the flow of the artesian wells has been followed by a notable decrease in the surface output of those streams leading from Cienegas."

The following diagram indicates the way in which the water has fallen in a certain typical well near Anaheim, which is located in the coastal plain, which is the largest body of underground water in Southern California. The water stood in this well at twenty-three feet from the surface in March, 1898, on August 1, 1905, it was 52 feet 7 inches, and on January 14, 1907, it was 48 feet 8 inches from the surface.

Mr. Mendenhall has written a number of special reports which have been published by the United States Geological Survey during the past four or five years. A request was made to the Director of the Geological Survey for Mr. Mendenhall to bring these records down to date in order to assist the City of Los Angeles in reaching the best conclusion relative to its water supply problem. Mr. Mendenhall did this work for the City in November, 1906, and his full report is published as Appendix A attached.

Diagram showing Variation of Water Level near Anaheim, Orange Co. Cal.



His conclusions are:

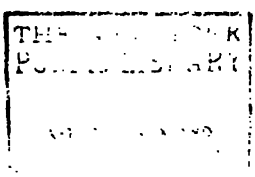
NEED OF OWENS VALLEY WATERS.

"The bearing of this situation upon the wisdom of Los Angeles' movement to secure Owens Valley waters may well be briefly discussed. Contiguous to Los Angeles on the south is the Coastal Plain, which contains the largest body of water-bearing land in Southern California, and but a short distance away to the east lies the San Gabriel basin. In the southern part of this basin, near El Monte, lies an area underlain by a valuable body of ground waters, which have not as yet been seriously taxed by development. These two regions are probably the best in the southern part of the State, in point of view of underground water supply, and both have been considered at various times, when the question of a supply for the City of Los Angeles to be secured from near-by points has been under discussion. The data which has already been presented proves that in that portion of the Coastal Plain which lies immediately south of Los Angeles, water levels have been declining during the past two years, in spite of the fact that these years have covered a period of very much more than normal rainfall. In an area farther to the southeast, near the San Gabriel Channel, water levels have recovered during this period, while still farther eastward in the vicinity of Anaheim water levels fell during the first year of heavy precipitation and rose during the second, while in the period from 1900 to 1904, a time of approximately average rainfall for this section of the State, moderate declines are recorded.

"Within the Coastal Plain there are at present about 100,000 acres of land under irrigation, while approximately four times that area is capable of irrigation if water were available for this purpose. But the ground water supply is clearly overtaxed with the developments at present carried out in at least a portion of this area, while in the greater part of it, it is probable that developments have been carried quite as far as they can be without danger of a constantly declining ground water level and a consequent constantly increasing cost of waters in use for irrigation. It is clearly not possible to develop permanently enough of these waters to irrigate the remaining lands capable of irrigation within the Coastal Plain.

"Under these circumstances, if the City of Los Angeles were to enter this field and establish pumping plants for the purpose of securing a supply of water adequate for domestic purposes, it must enter into competition with the agricultural interests already established there, and practically eliminate the possibility of further extending the agricultural areas. It is obviously unwise, even if the California laws, as at

COTTONWOOD CREEK IN AUGUST 1906
This stream flows into Owens Lake. It is owned by the City.



present interpreted, would permit of such a policy, for the City to develop, at the expense of its surrounding tributary agricultural districts, and its entry into the Coastal Plain will inevitably be at the expense of these districts.

"The situation in the San Gabriel Valley in the vicinity of El Monte differs somewhat from that in the Coastal Plain. Developments of the underground waters there are not as yet extensive, and the supply appears not to be overdrawn. It is indeed probable that it is capable of further developments without serious depletion; but, as in the case of the Coastal Plain, there are large areas of agricultural lands in the San Gabriel Valley itself, and in the edge of the Coastal Plain below the Paso de Bartolo, which can be reclaimed by the use of these waters, if it shall seem desirable to develop them further, and this use will be rendered impossible if the City enters the district and pumps out large and constantly increasing quantities to supply its own needs.

"Furthermore, there now head in and above the Paso de Bartolo a number of important canals, which are supplied by the waters that rise in and near the Pass, and which, in turn, supply irrigating waters to accessible lands in the region to the south and west. The effect of the development of underground waters in a region where under natural conditions the surplus rises to the surface in a series of springs, is to reduce the flow of these springs and as development proceeds eventually to cause their disappearance; springs of this type are extremely sensitive to the installation of pumping plants in their vicinity and since so many canals on and above the Paso de Bartolo are supplied exclusively by them, there is little doubt but that extensive developments there would affect the supply now taken by these canals, and so would lead to extended litigation, in which either the agricultural lands which utilize the canal waters would be deprived of their supply, or the City would lose its right to pump.

"During the dry period through which Southern California has lately passed, one of the canal systems heading here in the Pass was forced to install a pumping plant in order to keep its supply up to the normal. This fact indicates that but little, if any, more water now rises in the Paso de Bartolo than is required by the interests which utilize it, and indicates a strong probability that any developments which will tend to interfere with this supply will at once make themselves felt through a reduction of the flow of the natural springs.

"Since these two areas, the Paso de Bartolo and the Coastal Plain, are not only the best water-bearing districts near Los Angeles, but are the best in Southern California, obviously, if it is unwise to further tax them by additional developments, it would be still more unwise to invade

other of the water-bearing lands more remote from the City. So far as the ground water situation is concerned, therefore, the policy of the City in going to a distant source for its water supply, is not merely wise, but is absolutely necessary, if the City's future growth is not to be at the expense of neighboring communities."

The conclusion of this investigation was that, first, there is urgent need for an additional water supply; second, that the attempt should not be made to invade local fields for water; third, that the City could use ultimately to its advantage, within an area to be included within reasonable prospective boundaries, an amount as great as 500 cubic feet per second, or 25,000 miner's inches; fourth, that the future development and prosperity of this section will be measured largely by its available water supply. The estimates indicated not only that this conclusion could best be met from the Owens River Valley, but also that the cost per miner's inch of water obtained therefrom would be less than the cost of obtaining it from any other locality.

It has been proposed by some that the San Gabriel River above Azusa should be utilized for an additional water supply for the City of Los Angeles. This is based on recent flood discharge from that drainage basin. Unfortunately, the controlling factor in determining the adequacy of a water supply is governed by a cycle of dry years, rather than by a cycle of wet years. All the summer flow of the San Gabriel River is completely diverted and used for irrigation by some of the most highly productive citrus regions of Southern California, and the value of the products from these irrigated lands amounts to two millions of dollars annually. In dry years winter irrigation is practiced. Fortunately we have measurements extending over a period of ten years made by the United States Geological Survey on this stream, indicating both the amount of water diverted, and the surplus from this source.

The following table, taken from United States Geological Survey Water Supply Paper No. 81, called "California Hydrography," shows the amount of this surplus water of the San Gabriel River, including all flood water:

1896	11	second	feet,	or	550	inches
1897	104	"	"	"	5200	"
1898	2.5	"	"	"	125	"
1899	.13	"	"	"	6.5	"
1900	15	"	"	"	750	"
1901	83	"	"	"	4150	"
1902	4	"	"	"	200	"

1903	103.9	"	"	"	5195	"
1904	10.1	"	"	"	505	"
1905	167.0	"	"	"	8350	"
Ten-year mean					2503.15	miner's inches.

The surplus water passing these diversion canals debouches over the sands and gravels of the San Gabriel Valley, and, under ordinary conditions, is absorbed by them, and, percolating towards the San Gabriel Narrows, furnishes the water supply for the Norwalk, Whittier and Compton regions. An attempt to store these flood waters in the San Gabriel would probably lead to injury to and litigation with these communities. A power plant is built in the canyon of the San Gabriel River, which might be seriously interfered with if the flood water were stored and its winter water supply thus cut off. The capacity of this power canal is 100 second feet or 5,000 miner's inches. A great many other right of way applications have been filed upon and granted to the Power Companies.

There are no reservoir sites of value in the drainage basin of the San Gabriel River. The entire area has been mapped by the topographers of the Geological Survey, and the irrigators and land owners receiving their water supply from this stream would long since have constructed a reservoir in this basin if a suitable site existed and if the water supply had been adequate. I am, therefore, unable to see any merit in the proposition of storing the flood waters of the San Gabriel River for the relief of the City of Los Angeles.

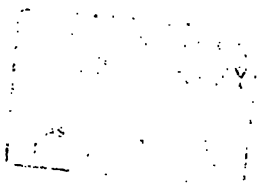
The Mojave River situation was considered in the Water Commissioners' Report of 1904-1905. It is therein stated that 40 second feet, or 2,000 miner's inches could be obtained from Victor reservoir. This would meet our demands for only four or five years. This river has been further investigated, and no occasion has been found for modifying the first report, which was to the effect that a temporary relief could be obtained at relatively high expense per miner's inch of water delivered by storing the flood waters of the Mojave River at the Victor Reservoir site, or in the Arrowhead reservoirs. It is to the advantage of the City of Los Angeles that the waters of the Mojave River should be used in the San Bernardino Valley in local development, as the City can get another supply at a cheaper rate per unit of volume from the Owens River, and is benefitted by the development of its tributary country.

FUTURE REQUIREMENTS.

It was stated above, that the total available supply of the City, including the water extracted from wells, was 71.5 cubic feet per second. A portion of this supply, however, was obtained from wells and might be considered as temporary. The minimum surface flow of the Los Angeles River during the summer of 1904 was 43 second feet, and from the Arroyo Seco at the Devil's gate, the flow was about two second feet, making 45 second feet as the available supply in a dry year from surface streams near Los Angeles for the entire Los Angeles, Hollywood and Pasadena districts. With a domestic water consumption of 150 gallons per capita, one million people would require 150 million gallons daily, or 232 cubic feet per second. Deducting the available supply from this 232 second feet consumption, we will have a deficiency, under these conditions, of 187 cubic feet per second, which should be supplied from some outside source. The present plan is to build an aqueduct with a net capacity of 400 cubic feet per second. We may, therefore, say that one million people will require about one-half of this supply, and that the remaining 200 cubic feet per second, or 10,000 miner's inches would be available for irrigation uses. The City of Los Angeles now covers 61.16 square miles, and it is highly probable that its boundaries will be greatly extended. It is absolutely necessary that Los Angeles now provide for domestic water for all time to come. There are now about 350,000 inhabitants within the possible limits of these extensions, and our numbers have been doubled within four years.

By a fortunate circumstance, practically the same amount of water is required for the irrigation of a square mile of citrus fruit, that is required for the domestic uses of a square mile of a city such as Los Angeles, so that these areas upon which surplus water at first may be used for horticulture, may become strictly urban regions without affecting the necessity for varying the water supply. The business sections of the city consume an inch to four acres, and an inch to eleven acres is the average for the entire City. As it is unnecessary to irrigate through the winter season, and as storage reservoirs in the San Fernando Valley are available for impounding the winter flow, for the next summer use, the 10,000 inches of water available for irrigation may be delivered in such method as may be required. This would give a six months summer supply of 20,000 inches, or an eight months summer supply of 15,000 inches. If an inch is made to serve five acres for irrigation, and with an eight

OWENS RIVER IN LOW STAGE AT PROPOSED POINT OF DIVERSION LOOKING DOWN STREAM AND TOWARD THE INYO MOUNTAINS.



months' annual supply, this would be sufficient for the irrigation of 75,000 acres of land.

In the San Fernando and Canada Valleys, and the country as far south and east as Eagle Rock, there are 106,440 acres of agricultural land. Between Ivanhoe and Santa Monica there are 40,550 acres, or a total of 146,990 acres, of which only 11,360 are now supplied with water, leaving 135,630 unprovided for. In the country between Pasadena, San Gabriel and the San Gabriel River, there are 43,200 acres additional. It will be seen, therefore, that in the country immediately adjacent and contiguous to the City of Los Angeles, there is an area twice as great as we can possibly hope to supply with water from the Los Angeles Aqueduct as planned, and this does not include the valuable lands south of the City.

OWENS RIVER PROJECT.

INCEPTION OF IDEA.

The idea of bringing the water of the Owens River to the City of Los Angeles originated in 1893 with Mr. Fred Eaton. Mr. Eaton was for several years engineer and superintendent of the Los Angeles City Water Company. He was subsequently City Engineer, and in 1893 he was engaged in the ranch business in Owens Valley, where he resided for a number of months. Mr. Eaton did not publicly discuss this idea. His training as an engineer, both for the City and with the Water Company, together with his general knowledge of the water situation in and around the City of Los Angeles, particularly qualified him to judge of the necessities of the case, and the merits of this project. He was Mayor of the City during the years 1899-1900. In the Fall of 1904 and the early Spring of 1905, Mr. Eaton on his own responsibility and at his own expense, began obtaining contracts and options on water-bearing property in Owens Valley. With these contracts and options in hand, he first presented the matter to representatives of the City of Los Angeles late in the Fall of 1904, and early in the year 1905. The first idea that Mr. Eaton had concerning the handling of the proposition, contemplated a combined private and municipal project, the City to receive 10,000 miner's inches of water for domestic uses, and the surplus water to be available for Mr. Eaton and his associates for disposal outside the City; this surplus water to pay toll for the use of the aqueduct, and all water to be available in transit for the benefit of the corporation for purposes of generating power. The aqueduct was to be built and paid for by the City and have a capacity of at least 20,000 inches. Mr. Eaton was to secure all necessary lands and water rights, and to deliver

the water rights without cost to the City. The Board of Water Commissioners, as well as other city officials, declined this, and insisted upon an exclusive municipal ownership and control. At this time, the U. S. Reclamation Service was investigating the Owens Valley Project, and had withdrawn all public lands there, including reservoir sites, and had filed on the water. Mr. Eaton's program was presented to the officials of the Reclamation Service, including Mr. F. H. Newell, chief engineer, and Mr. J. B. Lippincott, supervising engineer, for the first time in the Fall of 1904. Both these officers of the Reclamation Service took the stand that they could not aid the City of Los Angeles unless the project was exclusively a municipal one.

The Board of Water Commissioners detailed the superintendent to make an investigation of the water supply in the Owens River Valley in September, 1904, at which time of the year the waters of the streams in that valley are usually at their lowest ebb. This was followed up by a careful reconnaissance of the route, to determine the practicability of the constructing of a canal to bring the water to the City of Los Angeles. About three months was spent on this reconnaissance work. The superintendent reported favorably on the adequacy of the water supply and the feasibility of constructing a canal to bring it to the City, and the Board of Water Commissioners then asked him to make a preliminary estimate of the probable cost of such an enterprise, with a view to getting data on which to base a bond issue for the purchase of the Eaton water rights.

In April, 1905, Messrs. Fay and Elliott of the Water Board, accompanied by Mayor McAleer, City Attorney Mathews, and Messrs. Eaton and Mulholland, made a visit to the Owens River Valley for the purpose of further investigating the project, and of considering a proposal from Mr. Eaton to sell to the City certain options and contracts for the purchase of lands and water rights along the Owens River.

After carefully considering all available information concerning sources of water supply, sufficient for the needs of the City, both in and outside of Southern California, the Board became thoroughly convinced that the Owens River afforded the only adequate supply that could be obtained by the City at a cost which it would be justified in incurring. Having reached this conclusion, the Board entered into a contract with Mr. Eaton for the acquisition of the property embraced in the proposal submitted by him, and devoted the available funds of the Water Department for that purpose. Appendix "B" gives the official minutes of these proceedings. In this transaction, the City acquired all lands controlled by Mr. Eaton in what is known as the Rickey ranch, lying south of the north line of Township 10 South,

Range 34 E., M. D. M., embracing 22,670 acres, together with all water rights appurtenant thereto, including about 16 miles of frontage on the Owens River; also an easement permitting the use perpetually of 2684 acres in the Long Valley reservoir site for storage purposes, and in addition thereto, options held by Mr. Eaton on large tracts of land, with extensive frontage on the river below the Rickey property.

The commercial organizations of the City were taken into the full confidence of the Water Commissioners, and each step in this affair was fully considered by them. The minutes of the Board of Water Commissioners were public documents open to inspection.

The Chamber of Commerce appointed a special committee to investigate the plan of the Water Commissioners for an additional water supply, and the advisability of voting the $1,500,000 bond issue of September, 1905, for the purchase of water rights, making survey and starting construction. They reported as follows:

Los Angeles, California, September 1, 1905.

REPORT OF SPECIAL COMMITTEE OF CHAMBER OF COMMERCE ON OWENS RIVER WATER SUPPLY.

Board of Directors, Los Angeles Chamber of Commerce.

Gentlemen: Your committee appointed to investigate the plan proposed by the Board of Water Commissioners for bringing a supply of water from the Owens River Valley report as follows:

By careful investigation we have endeavored to secure all the information possible in connection with the proposed plans. We have conferred with the City officials, the Water Board, and with disinterested engineers and contractors. We have examined maps and Government reports, and have joined with othe rcommercial bodies in sending a special committee consisting of Messrs. H. C. Witmer, M. Lissner, and Fred A. Hines to the Owens River Valley to make a personal investigation, especially with reference to the quality of the water, of which a number of analyses were made by different chemists.

From this inquiry the conclusion of your committee may be thus summarized:

First: It is imperatively necessary to secure a new water supply if the development of this City is to be continued.

Second: The Owens River Valley is the only source that promises a permanent supply that will be sufficient.

Third: There is an ample supply for our needs, and the quality of the water is satisfactory.

Fourth: There are no difficult engineering problems presented in building the conduit needed. It is a large but simple proposition.

Fifth: The estimates of cost of construction are very liberal, and the total outlay will probably come well within the estimate of $21,-500,000 made by Mr. Mulholland, Engineer of the Water Department.

Sixth: While there will undoubtedly be more or less litigation as in all enterprises of this character, we believe that the rights sought to be acquired by the City can be successfully maintained and defended.

In connection with the above conclusions, we desire to express our satisfaction with the skill and marked ability displayed by those officials of the City who have had charge of its interests. A project of this kind conducted by a municipality usually fails, or becomes a matter of great expense by reason of premature knowledge of the plans.

We believe that they were sufficiently informed on all material points involved in the enterprise to justify the action taken by them. They do not expect to expend any more money than is necessary to conserve the City's interest until they shall have secured the approval of the entire plans by disinterested experts of the highest character.

We attach hereto a copy of letter received from the Water Board concerning same.

We heartily approve the entire project and recommend that the bonds be voted.

Respectfully submitted,

(Signed) W. J. WASHBURN,
(Signed) WILLIS H. BOOTH,
(Signed) A. B. CASS,
(Signed) WM. D. STEPHENS,
(Signed) JACOB BARUCH,
(Signed) FRED A. HINES,
Committee.

Prior to the time that money was available from the sale of bonds for the Los Angeles Aqueduct, and before the appointment of the Board of Public Works funds were advanced by the Water Commissioners to the extent of $233,865.53. This advance was made on the advice of the City Attorney and after careful deliberation with the City officials and commercial organizations. After the voting of the bonds in September, 1905, these funds were returned to the Water Department. The action of the Board of Water Commissioners was

Photo by Forbes, Copyrighted

LAKE MARY—TRIBUTARY TO OWENS RIVER.

courageous and patriotic throughout, and deserves the highest commendation. It was imperative that the lands and water rights necessary for the successful control of the situation should be obtained without general public discussion in the Owens Valley. When the subject was presented to the voters of Los Angeles, with a full explanation, in September, 1905, $1,500,000 in bonds was voted by them to pay for these lands and to continue the investigations and start construction, the vote being in favor of the issue, by a ratio of 14 to 1, which is probably the greatest majority that has ever been given to any bond issue in the City of Los Angeles.

FEDERAL WORK IN THE OWENS VALLEY.

After the passage of the Reclamation Act, June 17, 1902, general investigations were begun in all portions of the West for the selection of projects for construction. In California, the Klamath, Pit River, Cache Creek, King's River, Colorado River (from Needles to the Mexican line), Owens Valley and Sacramento Valley projects were all investigated.

In all of these districts, the water was filed upon under state law and withdrawals of the public lands made under the general provisions of the Reclamation Act. The Yuma project was adopted by the Secretary of the Interior in May, 1904, and the Klamath project in May, 1905. These two projects exhausted all money that was available for the construction of projects in California at that time. In the Fall of 1906, the Reclamation Service adopted the Orland Project on Stony Creek in the Sacramento Valley, thus initiating the Sacramento Project, which is one of the largest in the country. No promises or agreement were ever made upon the part of the Reclamation Service or any of its authorized agents to build any project in the Owens Valley. The Reclamation service stopped all work on the Owens Valley Project in January, 1906, and has not prosecuted any field work in that region since that time.

Section 8 of the Reclamation Act provides: "That nothing in this Act shall be construed as affecting or intended to affect or to in any way interfere with the laws of any State or territory relating to the control, appropriation, use or distribution of water used in irrigation, or any vested right acquired thereunder, and the Secretary of the Interior, in carrying out the provisions of this Act, shall proceed in conformity with such laws, and nothing herein shall in any way affect any right of any State or of the Federal Government or of any landowner, appropriator, or user of water in, to, or from any interstate stream or the waters thereof." The law of California with

reference to the perfecting of a water right is as follows: "Within sixty days after the notice is posted, the claimant must commence the divert the water, and must prosecute the work diligently and without excavation or construction of the works with which he intends to interruption to completion, unless temporarily interrupted by snow or rain." No construction was ever begun by the government and even surveys were discontinued more than a year ago. The Federal Government, therefore, has no valid water rights in the Owens Valley.

Under date of July 27, 1906, the following letter was sent to the Chief Engineer of the Reclamation Service by the President of the Board of Water Commissioners of the City of Los Angeles:

"Los Angeles, Cal., July 27, 1906.

"F. H. Newell, Esq., Chief Engineer, U. S. Reclamation Service, Washington, D. C.

My Dear Sir: The City of Los Angeles voted $1,500,000 for the purchase of riparian lands and the commencement of the work of constructing an aqueduct from the Owens Valley, by a ratio of fourteen to one, in September, 1905. We have now succeeded in completing our preliminary survey, have found no unforeseen difficulties, and believe the work is feasible.

"By an act of Congress approved June 30, 1906, the Federal Government granted to the City rights of way for conduits and reservoirs necessary for this enterprise. The Water Department has now purchased $750,000 worth of property and controls the riparian lands along the lower river for nearly forty miles. We favor returning to the Reclamation Service the amounts expended by it in Owens Valley.

"About June 27th the President addressed a letter to the Secretary of the Interior relative to this subject of which I enclose a copy. The following statement is contained therein:

"Senator Flint states that under the proposed law Los Angeles will be seeking to provide its water supply for the next half century, which will mean that at first there will be a large surplus, and that in order to keep their rights they will have to from the beginning draw the full amount of water (otherwise the water will be diverted to other uses and could not be obtained by the City), and while if the City did not need the water it would be proper that the other users should have it, yet it is a hundred or a thousand fold more important to the state and more valuable to the people as a whole if used by the City than if used by the people of Owens Valley."

"Our attention has been called to the rumor that Mr. L. H. Taylor, Supervising Engineer for Nevada, has made certain investigations for an "amended Federal Project" in the northern end of Owens Valley. Such a project would have intimate bearing on the plans and rights of the City, and we would be greatly obliged, if any such enterprise is proposed, to have the plans and reports presented to the Water Commissioners of the City of Los Angeles at the earliest date at which they can with propriety be shown us.

"While it has not been anonunced as yet, we may state to you that the City is now in possession of two important reservoir sites between Owens Valley and Los Angeles in which the surplus waters can be impounded. We also own by far the greater portion of the Long Valley Reservoir site near the head waters of the Owens River.

"Los Angeles needs all the additional water it can obtain. Our demand is in excess of the greatest available supply. It would be unfortunate if anything should be done by the Federal Government to interfere with the domestic water supply of the largest city of the Southwest, especially since its project is designed for public benefit, and we expect to proceed with this great work promptly.

"In this connection, we beg to inquire whether all the Reclamation Funds have not been allotted, so that money is not available for the construction of any other project.

"If it is necessary for us to modify our plans it is important that we should be informed at the earliest possible date.

Yours respectfully,

JNO. J. FAY, JR., *President.*
Board of Water Commissioners of the City of Los Angeles."

The following letter was received from the Chief Engineer:

DEPARTMENT OF THE INTERIOR
UNITED STATES RECLAMATION SERVICE

Washington, D. C., August 1, 1906.

"Mr. Jno. J. Fay, Jr., Board of Water Commissioners,
Los Angeles, Cal.

"Dear Sir: Your letter of July 27th has been received, making inquiry regarding the Owens Valley project.

"All of the papers in this matter have been sent forward to the Department, with recommendation, and I have not yet been informed

as to the action taken upon them. I have, therefore, taken the liberty of forwarding your letter to the Department, with request that answer be sent to you outlining as far as practicable the plans to be pursued. I assume that an answer will be sent directly to you from the Department.

Very truly yours,

F. H. NEWELL,
Chief Engineer.

No letter has ever been received from the Secretary of the Interior, either outlining his position, or acknowledging the receipt of this communication. The President and Congress, however, have indicated plainly their attitude towards the City of Los Angeles. The Act of Congress granting rights to the City is given as Appendix C., and the President's letter is given below. Certain correspondence, however, was presented to Senator Frank P. Flint by the Secretary of the Interior, including a letter from the Acting Director of the U. S. Geological Survey,addressed to the Secretary of the Interior, defining the present position of the Reclamation Service towards the Owens Valley Project, as follows:

DEPARTMENT OF THE INTERIOR.

United States Geological Survey.
Reclamation Service.
Washington, D. C., Jan. 25, 1907.

"The Honorable, The Secretary of the Interior.

Sir: I have the honor to acknowledge receipt of Departmental letter of the 16th inst. in relation to the Owens Valley Project. The Department asks whether I am still of the opinion that action should be taken as recommended in my letters of July 19 and August 2, 1906. and if so, why in my judgment, such action should be taken.

"In said letters I based my recommendation upon the fact that the funds available under the Reclamation Act would not admit of taking up for consideration any project in the Owens Valley.

"The conditions in regard to available funds have not changed and consequently I see no reason for modifying my former recommendations. In my letter of December 24, 1906, I stated that the petition concerning a sub-project known as the Fish Slough, had, in accordance with the suggestion of the Owens Valley Water Protective Association been referred to Mr. Taylor for report. This question has

heretofore been reported upon by Mr. Taylor so that nothing further is to be expected from him on this subject except a discussion of the matters presented in the petition.

"In my letter of July 19, 1906, I recommended that, subject to the provision of the Act of June 30, 1906 (34 Stat. 801), for the benefit of the City of Los Angeles, the lands withdrawn for reclamation purposes in the Owens Valley project, be restored to entry. I did not in that letter except the lands which would be available under the Fish Slough Project, because it would involve holding in reservation for an indefinite period a considerable area of land, a policy which has not heretofore been adopted by the Department, although heretofore recommended in several cases.

"If the Department is disposed to adopt the policy of holding lands in reservation for possible future projects, this office will prepare a list of lands to be retained for the Fish Slough project in making the restoration contemplated by the Act of June 30, upon the payment of $14,000 by the City of Los Angeles, to cover the expenses of the Government in connection with the Owens Valley Project.

Very respectfully,

H. C. RIZER,
Acting Director.

As far as known no further action has been taken by the Department. As the City has filed upon all surplus water under the state law and has followed this up with extensive surveys and construction, and has also become a very large riparian owner of these waters and has bought the principal reservoir sites it is not apparent how the Government could proceed in view of the law and the President's opinion.

The law which provides that individuals and corporations may file on rights of way for canals, reservoirs and power plants, does not plainly include a right for a municipality to file, and as a large portion of the area to be traversed by this aqueduct is over public lands, it was deemed necessary to obtain certain specific authority from Congress, in order for the City to obtain title to these rights of way. Accordingly, the Chamber of Commerce, in June, 1906, appointed a committee consisting of Messrs. W. J. Washburn, J. O. Koepfli, Wm. Mulholland and W. B. Mathews, to go to Washington for the purpose of requesting such an act from Congress. They were materially aided in their work by Chas. D. Walcott, Director of the Geological Survey, F. H. Newell, Chief Engineer of the Reclamation Service, and Gifford Pinchot, Chief Forester. Senator Flint was of great service in these

negotiations. An interview was obtained with the President, and on June 25th, 1906, in the presence of these gentlemen, he dictated the following letter to the Secretary of the Interior:

"The White House, Washington, June 25, 1906.

"My Dear Mr. Secretary:

As I think it best that there should be a record of our attitude in the Los Angeles Water Supply Bill, I am dictating this letter to you in your presence, and that of Senator Flint on behalf of the California Delegation, of Director Walcott of the Geological Survey, and of Chief Forester Pinchot. The question is whether the City of Los Angeles should be prohibited from using the water it will obtain under this bill for irrigation purposes. Your feeling is that it should be so prohibited because the passage of the bill without the prohibition might establish a monopoly in the municipality of Los Angeles to use the surplus of the water thus acquired beyond the amount actually used for drinking purposes, for some irrigation scheme.

"Senator Flint states that under the proposed law Los Angeles will be seeking to provide its water supply for the next half century, which will mean that at first there will be a large surplus, and that in order to keep their rights they will have to from the beginning draw the full amount of water (otherwise the water will be diverted to other uses and could not be obtained by the city) and while if the City did not need the water it would be proper that the other users should have it, yet it is a hundred or a thousand fold more important to the state and more valuable to the people as a whole if used by the City than if used by the people of Owens Valley. Senator Flint further says that the same water that is used for drinking and washing is also used on innumerable little plots of land in and around Los Angeles for gardening and similar purposes, and that to prohibit this would so nearly destroy the value of the bill as to make it an open question whether the City could or would go on with the project; it being open to doubt whether the words "domestic use" would cover irrigation of this kind.

"Messrs. Walcott and Pinchot state that there is no objection to permitting Los Angeles to use the water for irrigating purposes so far as there is a surplusage after the City's drinking, washing, fire and other needs have been met. They feel that no monopoly in an offensive sense is created by municipal ownership of the water as obtained under this bill, and that as a matter of fact, to attempt to deprive the City of Los Angeles of the right to use the water for irrigation would mean that for many years no use whatever could be

Photo by Forbes, Copyrighted

KEARSARGE PEAK IN OWENS RIVER BASIN NEAR INDEPENDENCE.

made by it of the surplus water beyond that required for drinking and similar purposes.

"I am informed by Senator Flint that the law of California provides that if a municipality sells water to people outside the municipality, it must be at same rate that it sells to those within the municipality.

"I am also impressed by the fact that the chief opposition to this bill, aside from the opposition of the few settlers in Owens Valley (whose interest is genuine, but whose interest must unfortunately be disregarded in view of the infinitely greater interest to be served by putting the water in Los Angeles), come from certain private power companies whose object evidently is for their own pecuniary interest to prevent the municipality from furnishing its own water. The people at the head of these power companies are doubtless respectable citizens, and if there is no law they have the right to seek their own pecuniary advantage in securing the control of this necessary of life for the City. Nevertheless, their opposition seems to me to afford one of the strongest arguments for passing the law, inasmuch as it ought not to be within the power of private individuals to control such a necessary of life as against the municipality itself.

"Under the circumstances, I decide, in accordance with the recommendations of the Director of the Geological Survey and the Chief of the Forestry Service, that the bill be approved, with the prohibition against the use of the water by municipality for irrigation struck out. I request, however, that there be put in the bill a prohibition against the City of Los Angeles ever selling or letting to any corporation or individual except a municipality, the right for that corporation or the individual itself to sell or sublet the water given to it or him by the City for irrigation purposes.

Sincerely yours,

THEODORE ROOSEVELT.

P. S.—Having read the above aloud, I now find that everybody agrees to it,—you Mr. Secretary, as well as Senator Flint, Director Walcott and Mr. Pinchot, and therefore I submit it with a far more satisfied heart than when I started to dictate this letter."

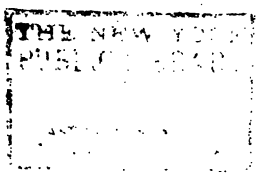
As a result of this conference, a Right of Way Act was passed (see Appendix C), which granted free right of use to the City of Los Angeles of all public lands required for canals, reservoirs and power plants in Inyo, Kern and Los Angeles counties, State of California, subject to valid existing rights. The Act provides that in the event

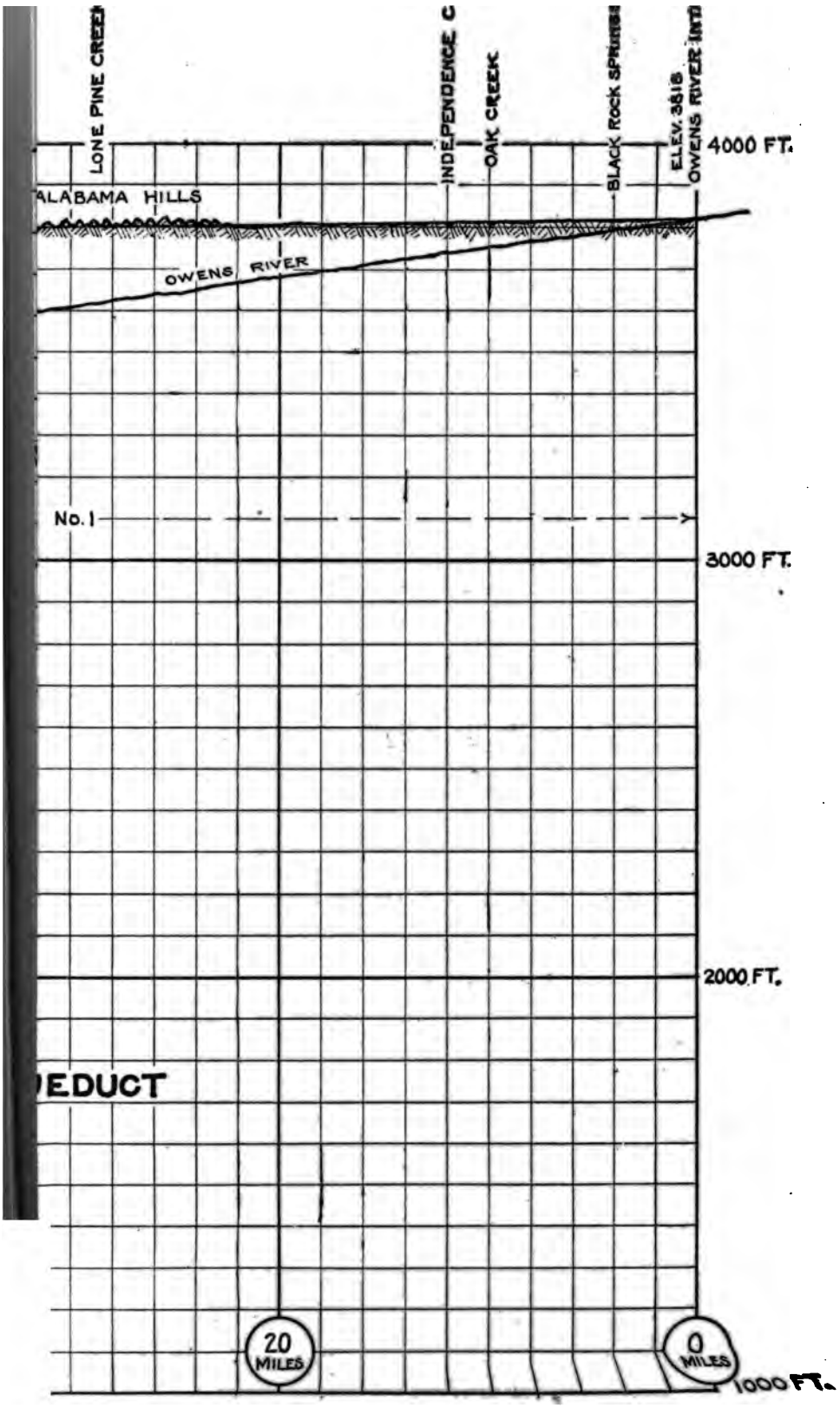
the Secretary of the Interior shall abandon the Reclamation Project known as the Owens Valley Project of the Federal Government, the City of Los Angeles shall pay to the Secretary of the Interior, for the account of the Reclamation fund, the amount expended by the Reclamation Service for preliminary surveys, examinations, etc., not exceeding $14,000, and in consideration of said payment, the City of Los Angeles is to have the benefit of the use of the maps and field notes of the surveys, and the preference right to acquire at any time within three years from the approval of this Act, any lands now reserved by the United States under the terms of said Reclamation Act in connection with said project, necessary for storage or rights of way purposes, upon the payment of $1.25 per acre for the same. Section 6 of said Act provides that the City of Los Angeles is prohibited from ever selling or letting to any corporation or individual, except a municipality, the right for such corporation or individual to sell or sublet the water sold or given to it or him by the city.

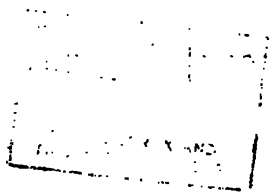
The President, in order to still further assist the City of Los Angeles, by an Executive order, withdrew all lands in bulk along the line of the proposed aqueduct and also in the Owens Valley, which might be of possible use to the City, and which might be filed upon by individuals or corporations prior to the time when the City could complete its surveys and file definite rights of way maps, as required by the Department. This withdrawal has been of great advantage to the City. Additional withdrawals have been made by Executive order on several occasions, and a disposition manifested to assist the City of Los Angeles in every possible way. The details concerning these lands are given under the discussion of land purchases.

In the late Fall of 1904, J. B. Lippincott, at that time Supervising Engineer for the Reclamation Service, recommended that the records of the stream measurements and the surveys of the Reclamation Service in Owens Valley should be given to the City in order to aid the Water Board in reaching an intelligent judgment as to the advisability of the City of Los Angeles undertaking the construction of a municipal enterprise therein. Thereupon, the Chief Engineer of the Reclamation Service gave these records to the Superintendent of the Water Department, and they are the only records that have ever been given by officers of the Reclamation Service to the City of Los Angeles. This data was largely published at the time and since then the remainder has been published. At the present time, the hydrographic branch of the Geological Survey is making extensive stream measurements and a study of the water supply of Owens Valley, in co-opera-

BLACK ROCK SPRING IN OWENS VALLEY ON THE RICKEY RANCH
which was purchased by the City. This spring flows 1,000 miner's inches.




LONE PINE CREEK
INDEPENDENCE C
OAK CREEK
BLACK ROCK SPRINGS
ELEV. 3818
OWENS RIVER INTO
4000 FT.
ALABAMA HILLS
OWENS RIVER
No. 1
3000 FT.
2000 FT.
EDUCT
20 MILES
0 MILES
1000 FT.



tion with the City of Los Angeles, the City paying the field expenses, and the Government employing the engineers who do the work under directions from Washington. Mr. W. B. Clapp, Hydrographer, U. S. G. S. at Los Angeles, has charge of this work. It is of great value to the City. This same organization is making systematic analysis of the water of the Owens River; a chemical analysis is made once a week and sanitary analysis once a month. The results are all reassuring. The topographic branch of the Geological Survey has also extended its work into the Owens Valley, and has particularly run a line of precise levels from San Pedro to Bishop. This data is of great value to the City. The work of the topographic branch of the Geological Survey was in large part the basis upon which the first estimates as to the cost of the Owens Valley Project were built. Throughout this entire affair, the Federal Government, and particularly the Forestry Bureau and the Geological Survey have rendered very material assistance to the City of Los Angeles.

HYDROGRAPHY.

The Owens Valley is situated in Inyo County, California, and lies *entirely within the boundary of this state.* The northernmost point of this drainage basin adjoins with the Yosemite National Park. Its western boundary is the crest of the Sierra Nevadas, the loftiest range in the United States. Along this crest there are more than forty peaks in excess of an elevation of 13,000 feet, of which the highest is Mount Whitney with an altitude of 14,500 feet. The elevation of Owens Lake into which the Owens River drains is 3567 feet. The lake has no outlet. On the north and east the valley is bounded by the Inyo and White Mountain range, the elevation of the crest of which is over 10,000 feet. The total area of this drainage basin tributary to Owens Lake is 2810 square miles. Under previous geological conditions this river proceeded in a southerly direction into the Mojave Desert; the flow of the river south of Owens Lake has been interrupted by geological changes, the elevation of this low pass being 3,710 feet or about 143 feet above the lake level. There are no interrupting ranges of mountains between the Owens Valley and the City of Los Angeles with the exception of the coast range immediately north of the City. There are, therefore, two controlling summits that have to be overcome, that at the Haiwee Reservoir site which is accomplished by a diversion from the river at a point on the river about 35 miles north of the lake, and the other summit is on the south side of the Antelope Valley. Because of these controlling divides, light grades are used in locating the line.

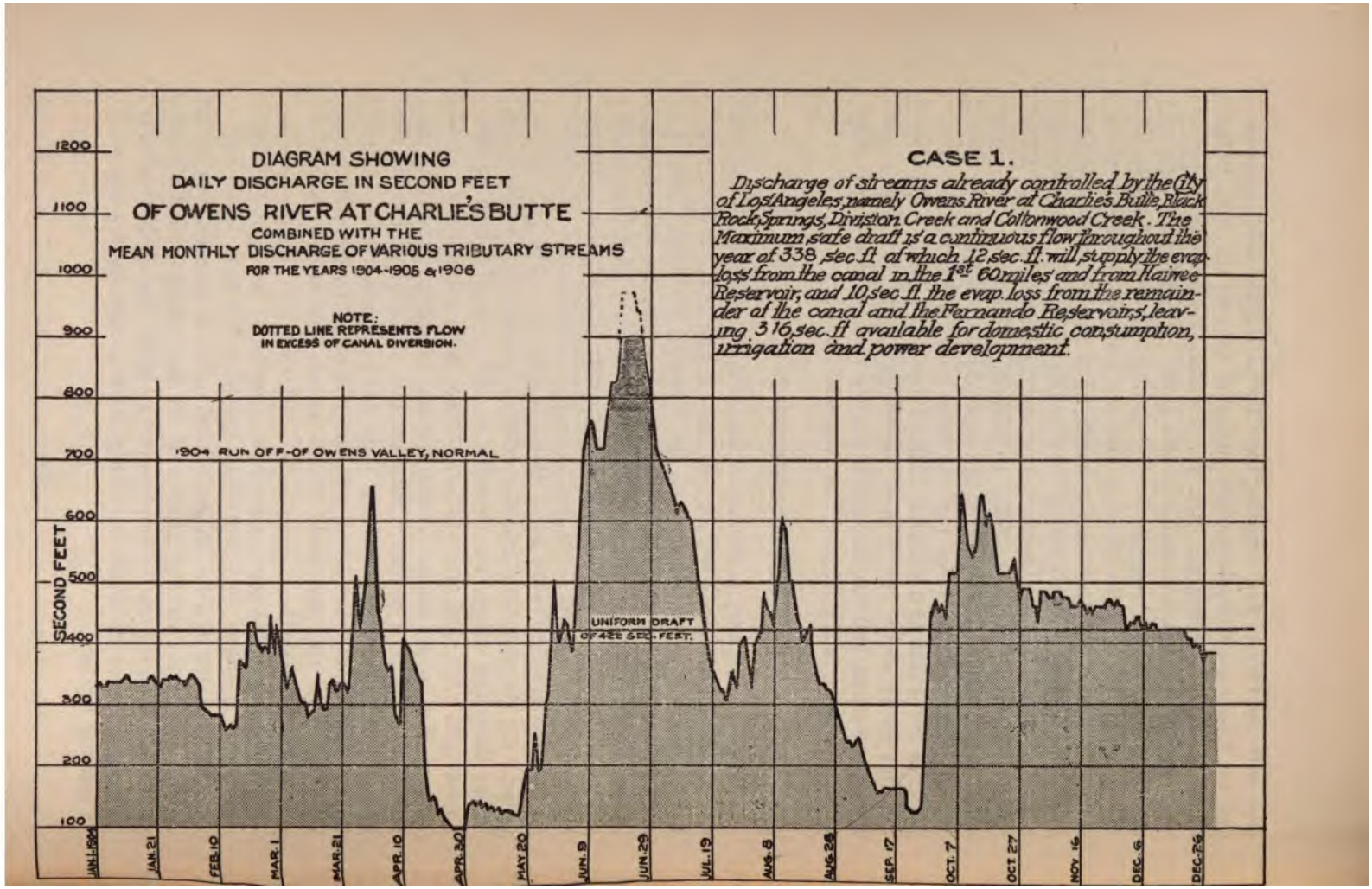
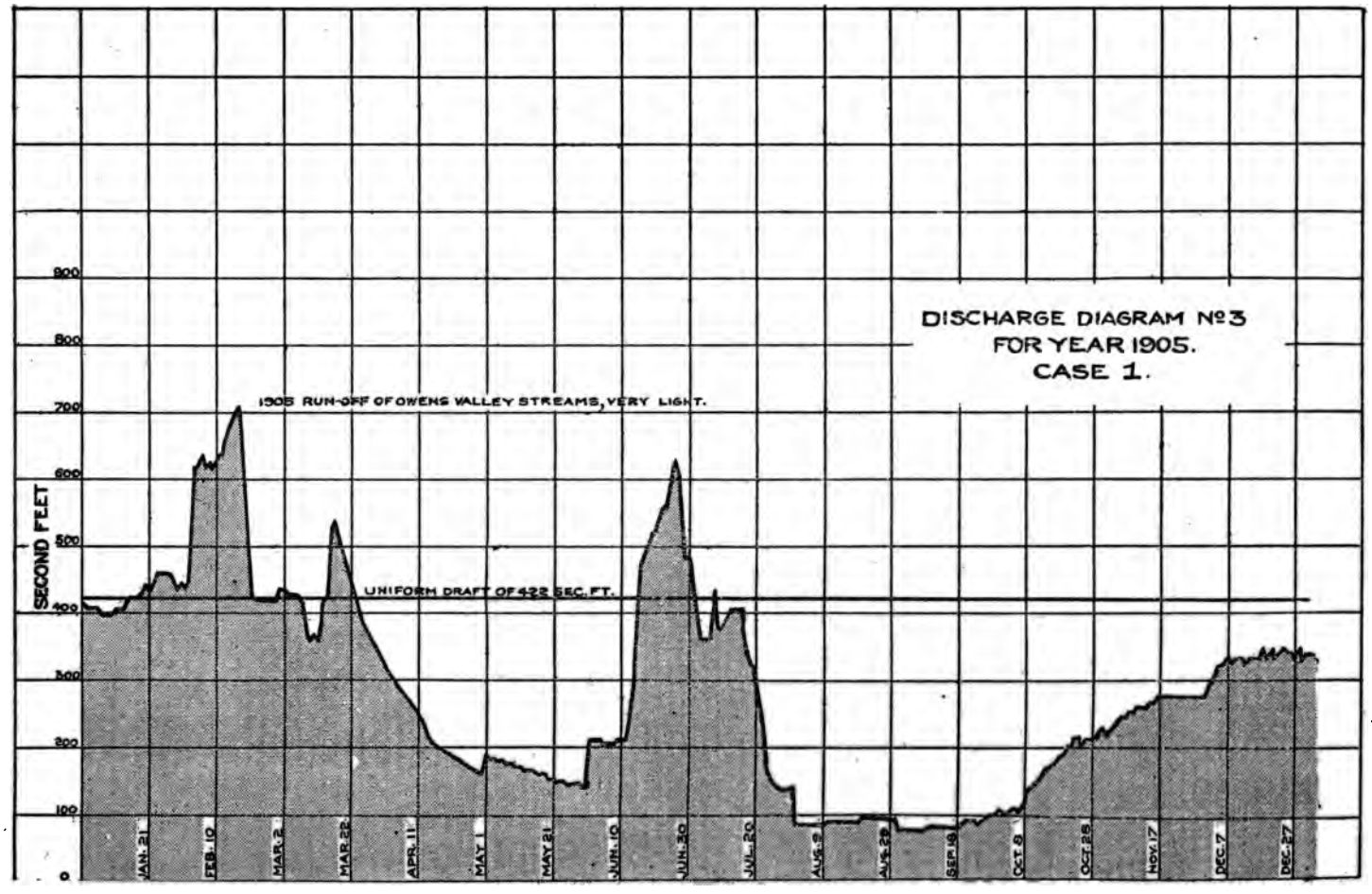


DIAGRAM SHOWING
DAILY DISCHARGE IN SECOND FEET
OF OWENS RIVER AT CHARLIE'S BUTTE
COMBINED WITH THE
MEAN MONTHLY DISCHARGE OF VARIOUS TRIBUTARY STREAMS
FOR THE YEARS 1904-1905 & 1906
NOTE:
DOTTED LINE REPRESENTS FLOW
IN EXCESS OF CANAL DIVERSION.
CASE 1.
Discharge of streams already controlled by the City of Los Angeles, namely Owens River at Charlie's Butte, Black Rock Springs, Division Creek and Cottonwood Creek. The Maximum safe draft is a continuous flow throughout the year of 338 sec. ft. of which 12 sec. ft. will supply the evap. loss from the canal in the 1st 60 miles and from Haiwee Reservoir, and 10 sec. ft. the evap. loss from the remainder of the canal and the Fernando Reservoirs, leaving 316 sec. ft available for domestic consumption, irrigation and power development.
1904 RUN OFF-OF OWENS VALLEY, NORMAL
UNIFORM DRAFT OF 422 SEC. FEET.
SECOND FEET
1200
1100
1000
900
800
700
600
500
400
300
200
100
JAN. 1-1904
JAN. 21
FEB. 10
MAR. 1
MAR. 21
APR. 10
APR. 30
MAY 20
JUN. 9
JUN. 29
JUL. 19
AUG. 8
AUG. 28
SEP. 17
OCT. 7
OCT. 27
NOV. 16
DEC. 6
DEC. 26

The prevailing grade is about one foot per mile, until the coast range is pierced with a tunnel 26,000 feet long at Elizabeth Lake at an elevation of 2950 feet. In a state as rugged as California it is a remarkable topographic condition that will permit of such a length of line free from prohibitory obstacles.

The general conditions of rainfall in California are well understood,—the dry season beginning about the first of April and extending until the first of October, and the wet season from the first of October to the first of April. Little rain falls during the summer growing season. The moisture which is precipitated is derived from the Pacific Ocean and is carried east. It is forced over the crests of the mountain ranges which it encounters. The warm humid air from the Pacific during the winter months is chilled in passing over these crests particularly in the case of the Sierra Nevadas. This chilling process condenses the moisture in the form of snow and rain. After the crest of the Sierras is passed, the valleys and mountains to the east thereof being lower in elevation, the tendency is for the temperature of the atmosphere to rise and precipitation ceases. The increase in rainfall passing from the coast to the crest of the Sierras is very great. Generally speaking, the average annual rainfall increases at the rate of from one-half to three-fourths of an inch in depth for each 100 feet rise in elevation on the west side of the range. The rain storms are forced over the crest and a short distance beyond before a marked decrease in precipitation occurs. We therefore have in the basin of the Owens River a precipitation ranging from 50 to 70 inches on the crest of the mountains, heavy deposits of snow and rain on the high eastern face of the range, and a rainfall in the Owens Valley which averages but five inches. The precipitation in the Inyo mountains is possibly one-third the amount of that occurring on the high Sierras. No records are known of on these latter mountains. The water supply, therefore, is all derived from the eastern face and crest of the Sierra Nevadas.

There is little contribution to the streams from the valley itself and practically nothing from the ranges to the east of the valley. Because of the great elevation of the Sierra Nevadas, the precipitation is mostly in the form of snow, great banks forming on the crests and in the high mountain canyons. The snow banks often consolidate into small glaciers or ice fields which are perpetual in their character and which are the permanent source of late summer stream supply. The cold which is consequent to the high elevation of the range prevents an extensive melting of the snow except on the lower foot hills during the winter months. The summer thaw extending from the


DISCHARGE DIAGRAM Nº3
FOR YEAR 1905.
CASE 1.
1905 RUN-OFF OF OWENS VALLEY STREAMS, VERY LIGHT.
UNIFORM DRAFT OF 422 SEC. FT.
SECOND FEET
900
800
700
600
500
400
300
200
100
0
JAN. 21
FEB. 10
MAR. 2
MAR. 22
APR. 11
MAY 1
MAY 21
JUN. 10
JUN. 30
JUL. 20
AUG. 9
AUG. 29
SEP. 18
OCT. 8
OCT. 28
NOV. 17
DEC. 7
DEC. 27

THE EASTERN FACE OF MT. WHITNEY IN THE BASIN OF OWENS RIVER—
Photo by Forbes, Copyrighted Elevation 14,500 ft.

first of May until the first of August produces an annual flood flow of the streams. As this melting period is during the dry season of the year the streams are free from torrential floods, the annual rise occurring gradually and receding with equal uniformity. This is a natural condition which greatly increases the value of this water supply in that the period of greatest supply is coincident with that of the greatest summer demand. Reference is made to the report of Mr. Charles H. Lee, attached as Appendix D. for a full discussion of these hydrographic features.

The total population of Inyo County including all of Owens Valley in the year 1880 was 2928 and in 1900 was 4377. The valuation of the entire county at the assessment made in 1906 was $2,600,000. This is in marked contrast to the growth of Los Angeles County, the population of which in 1880 was 33,381 souls and in 1905 with reduced county boundaries, 375,000. The assessed valuation of the City alone in 1906 was $203,000,000.

The Owens River basin drains into Owens Lake which is saline and has an area, according to the United States Land Office Survey of 96 square miles or 61,440 acres. Observations of evaporation in the Mojave Desert show an annual loss from the water surface of 7 feet. This would indicate, therefore, a permanent loss from this lake of 430,000 acre-feet which is equivalent to a constant flow of 594 second feet or 29,700 miners' inches. As the area of this lake must have adjusted itself between an annual evaporation and an annual inflow, it is considered safe to assume that these figures fairly represent the mean annual output in water of the entire Owens River basin. The lake has fallen during the last few years, partly due to the irrigation uses of water in the valley, but in greater part because of an unusual cycle of dry years. During the past two wet years, however, the lake has risen in elevation.

Unless an extensive system of storage reservoirs can be found in a drainage basin, the output therefrom which may be relied upon is controlled by a group of minimum years instead of by the output of a group of wet, or even of average years. For instance upon a stream such as the San Gabriel, upon which no good reservoir sites exist, a period of dry years absolutely controls, and renders this a wholly unreliable source.* It is not even economical to hold over in reservoirs situated where the evaporation is great, flood waters from wet seasons for a long period of years, because the great bulk of the storage ca-

*See page 14, where a table is given of the surplus water of the San Gabriel River.

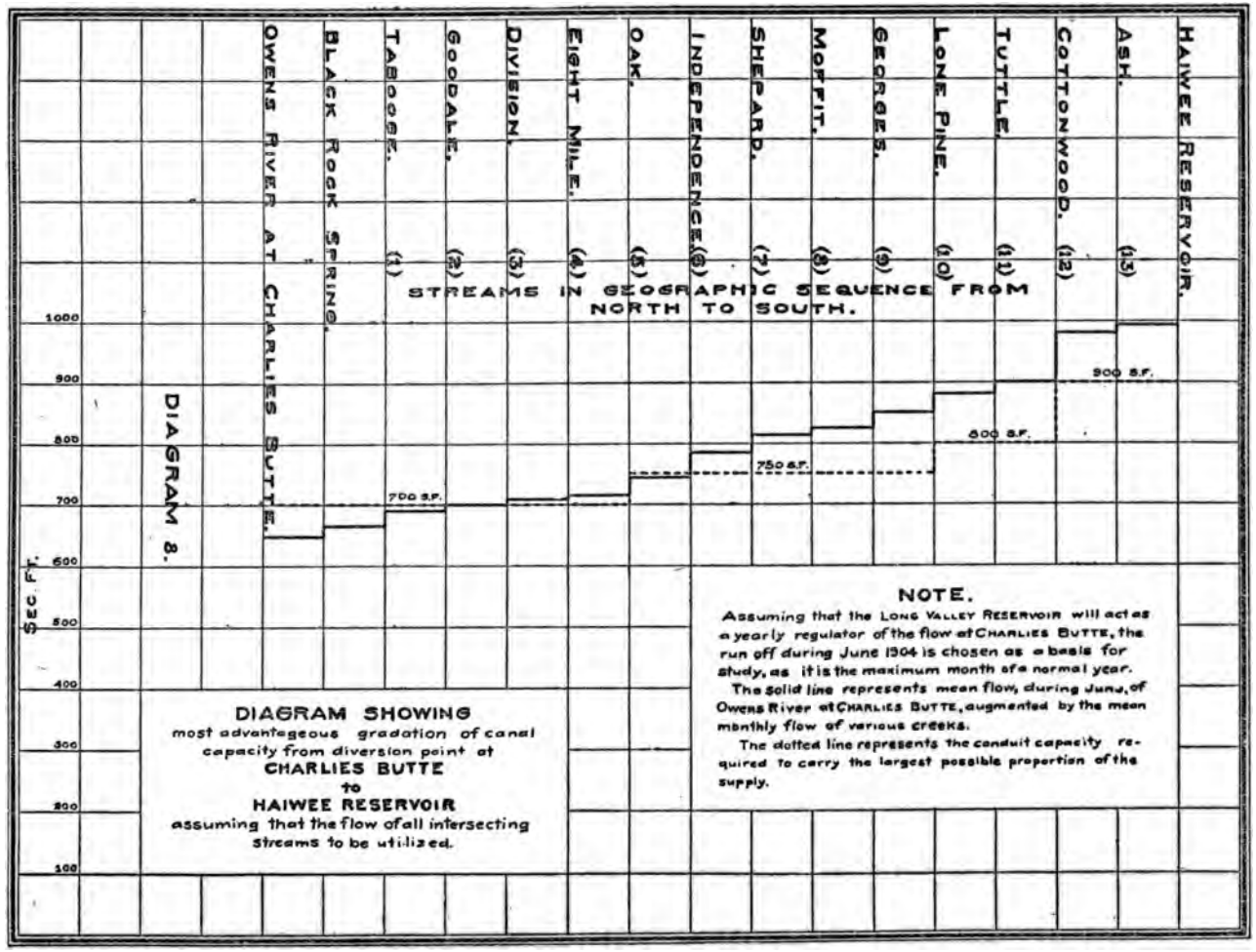


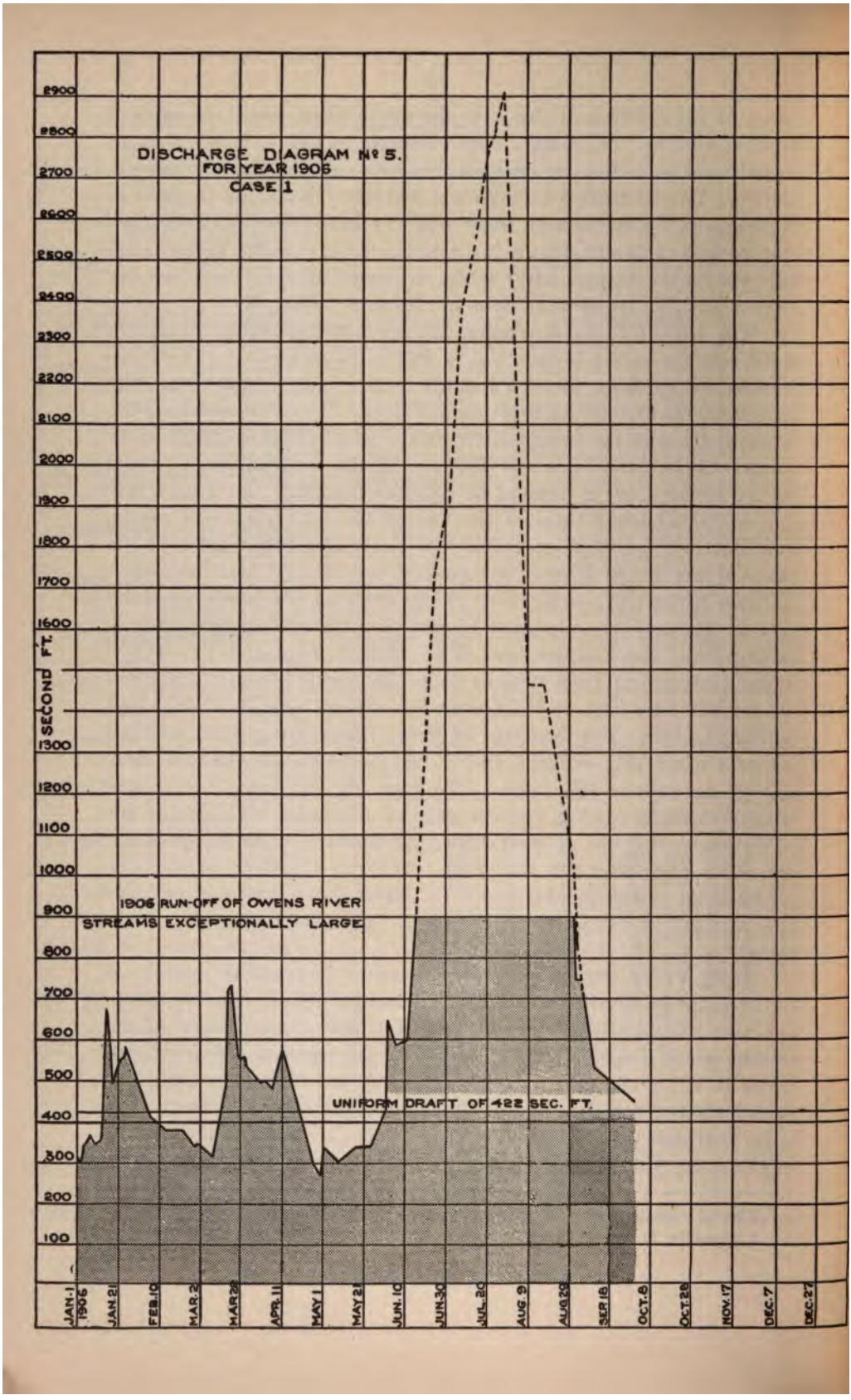
DIAGRAM 8.
DIAGRAM SHOWING
most advantegeous gradation of canal capacity from diversion point at
CHARLIES BUTTE
to
HAIWEE RESERVOIR
assuming that the flow of all intersecting streams to be utilized.
STREAMS IN GEOGRAPHIC SEQUENCE FROM NORTH TO SOUTH.
(1) TABOOSE.
(2) GOODALE.
(3) DIVISION.
(4) EIGHT MILE.
(5) OAK.
(6) INDEPENDENCE.
(7) SHEPARD.
(8) MOFFIT.
(9) GEORGES.
(10) LONE PINE.
(11) TUTTLE.
(12) COTTONWOOD.
(13) ASH.
HAIWEE RESERVOIR.
OWENS RIVER AT CHARLIES BUTTE.
BLACK ROCK SPRING.
700 S.F.
750 S.F.
800 S.F.
900 S.F.
SEC. FT.
1000
900
800
700
600
500
400
300
200
100
NOTE.
Assuming that the LONG VALLEY RESERVOIR will act as a yearly regulator of the flow at CHARLIES BUTTE, the run off during June 1904 is chosen as a basis for study, as it is the maximum month of a normal year.
The solid line represents mean flow, during June, of Owens River at CHARLIES BUTTE, augmented by the mean monthly flow of various creeks.
The dotted line represents the conduit capacity required to carry the largest possible proportion of the supply.

pacity in the reservoir is always in the upper levels where the exposed area is greatest. The Long Valley reservoir on Owens River is at an elevation of 7000 feet and evaporation losses will be about 3 feet per annum. The fluctuation between wet and dry years is not so great as in Southern California and water will not have to be held for such long periods of drouth. This is in marked contrast with the Victor reservoir site on the Mojave River where the evaporation loss is 7 feet per annum and the drouth conditions much more prolonged.

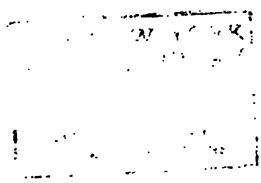
The United States Geological Survey began a system of stream measurements in the Owens Valley in the Fall of 1903. These observations have been continued down to date and represent the only measurements that are available on this river. However, adjoining the drainage basin of the Owens River on the west is that of Kings River which extends from Mount Williamson on the south to Mt. Goddard on the North, a crest distance of 40 miles adjoining the central portion of the drainage basin of the Owens River.‡ The same storms that contribute moisture to the Owens River also contribute it to the basin of the Kings River. Fortunately one of the oldest and most accurate records of stream flow in the State of California has been kept on Kings River,—the State Engineering Department of California having made the measurements from 1878 to 1884 and the United States Government from 1895 to date. During the three years when the records were kept on the Owens River they were also being kept on Kings River. The discharge of Kings River during 1904 was 106 per cent of its 16-year mean and the discharge during the year 1905 was 73 per cent of this mean. The year 1906 was one of excessive stream discharge, being 210 per cent of the mean. There are but two years during the 16 year period of observation on Kings River that were drier than the year 1905. We are, therefore, particularly fortunate in having records on Owens River for a dry year, an average year and a wet year. This data is fully discussed in Mr. Lee's report.*

Long Valley Reservoir site is situated in the northerly portion of the drainage basin of Owens River. It has 391 square miles of drainage area tributary to it. A dam 100 feet high above the bed of the stream would impound 83,485 acre-feet, an acre-foot being enough water to cover one acre one foot deep. A 120 foot dam would impound 160,000 acre-feet and a 140 foot dam 260,000 acre-feet. This latter is greater than any existing reservoir in California. The province of the Long Valley reservoir site would be to hold over waters from

‡See the general map for the location of these basins.
*Appendix D.


DISCHARGE DIAGRAM Nº 5.
FOR YEAR 1906
CASE 1
SECOND FT.
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
1906 RUN-OFF OF OWENS RIVER
STREAMS EXCEPTIONALLY LARGE
UNIFORM DRAFT OF 422 SEC. FT.
JAN. 1 1906
JAN. 21
FEB. 10
MAR. 2
MAR. 22
APR. 11
MAY 1
MAY 21
JUN. 10
JUN. 30
JUL. 20
AUG. 9
AUG. 29
SEP. 18
OCT. 8
OCT. 28
NOV. 17
DEC. 7
DEC. 27

FAIRMOUNT RESERVOIR AND DAM SITE AT THE NORTH END
OF THE PROPOSED ELIZABETH LAKE TUNNEL.

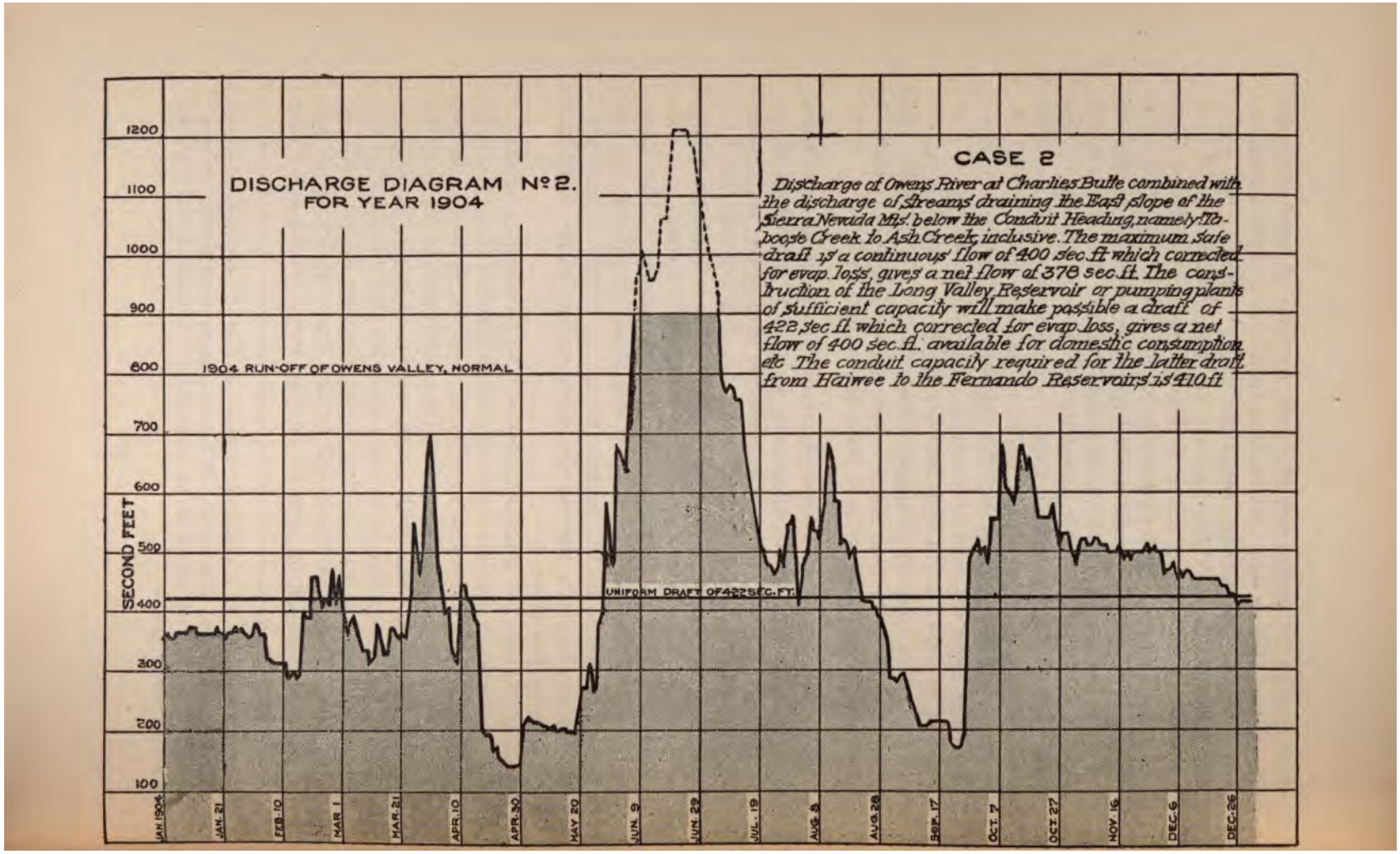


years of excessive stream flow like 1906, for years of deficient stream flow such as 1898 or 1905. Its function, therefore, is purely annual, intended to meet unfavorable conditions during cycles of dry years. Water from the Long Valley reservoir site when liberated would flow down the natural channel of the river to the point of diversion from the Owens River at Charley's Butte at an elevation of 3814 feet. At this point the diversion canal would begin with an initial capacity of 700 cubic feet per second or 35,000 miners' inches. This canal would be increased in capacity as it passed the various tributaries of Owens River until at the Cottonwood Creek crossing its capacity would be increased to 900 cubic feet per second or 45,000 miner's inches. It continues with this capacity until the Haiwee Reservoir site is reached sixty miles below the point of diversion. The Haiwee Reservoir with a dam of 75 feet in height at its southern end has a capacity of 64,000 acre-feet. This reservoir commands all possible sources of supply and is near enough to the head not to require a great length of conduit of large capacity necessary to carry flood flow to it.

The province of the Haiwee Reservoir site is for the regulation of the monthly flood flow. All ordinary floods can be conveyed to the Haiwee reservoir site by the large canal, and regulated to the capacity of the aqueduct below the Haiwee reservoir. Below the Haiwee Reservoir site the conduit has a capacity of 430 cubic feet per second and it is proposed to continue this uniformly through to a reservoir site on the south side of the Antelope Valley near Fairmont.* The Long Valley and the Haiwee Reservoir site will permit of utilizing this 140 miles of conduit to its full capacity for the 12 months of each year. The Haiwee Reservoir site will also guard against breaks which may occur in the line above it.

The province of Fairmont Reservoir is to insure a supply in spite of breaks in the line above and also to permit varying the daily flow in the conduit below it in order to meet the fluctuating hourly and daily demands for power. The Fairmont Reservoir site is at the head of the power line. With a dam 100 feet in height, it has a capacity of 6,656 acre-feet or an eight days' full flow of 400 sec. feet. The elevation of the water surface in the Fairmont Reservoir will be 3,025 feet. The outlet tunnel will be run from the bottom of this reservoir site through the crest of the coast range into the San Fran-

*The aqueduct is designed to deliver 400 sec. ft. net from the San Fernando reservoirs. The 30 sec. ft. excess capacity is to provide for evaporation losses and to permit of an accumulation of water at the Fairmont reservoir when required.

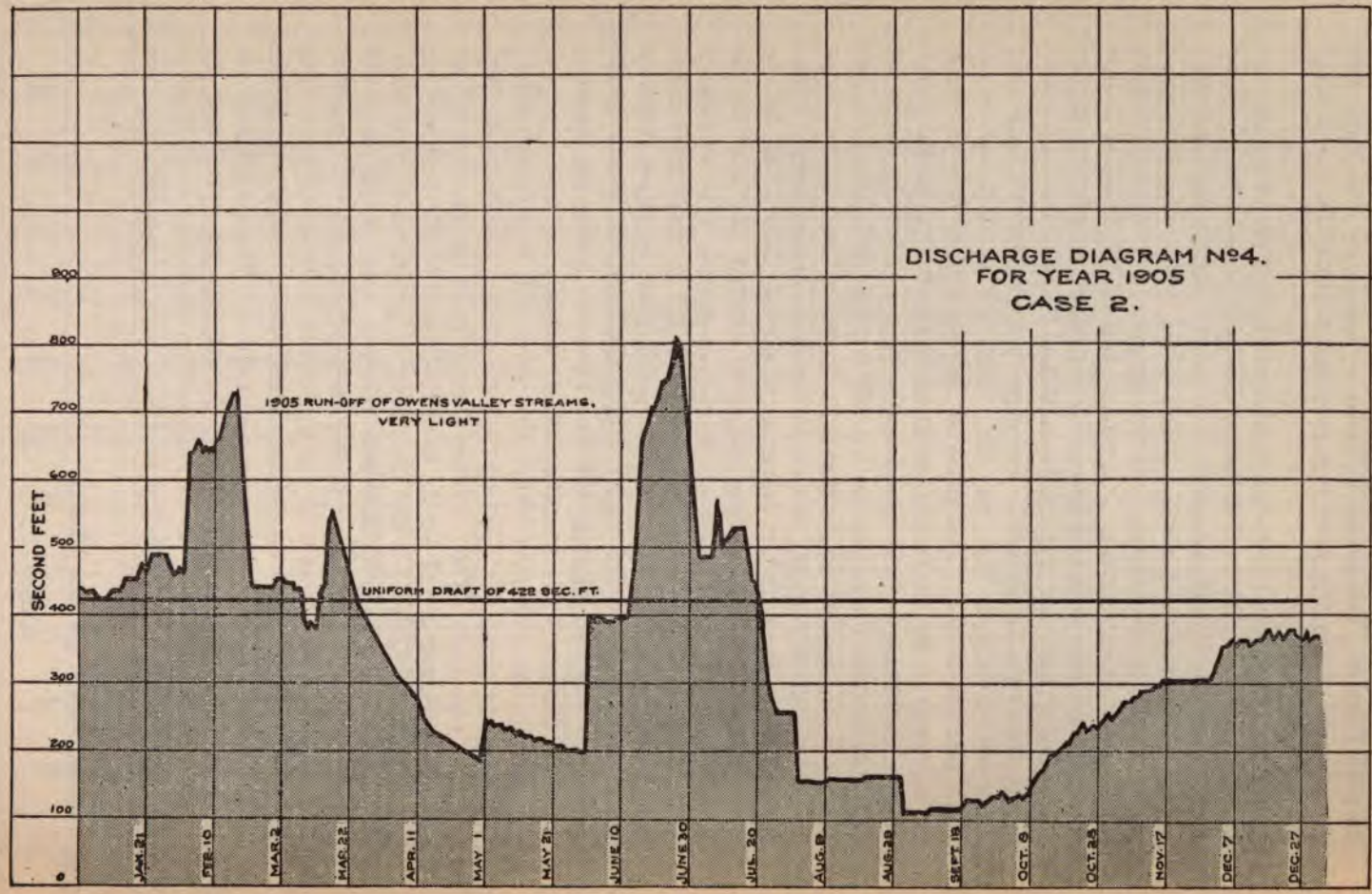

DISCHARGE DIAGRAM Nº 2.
FOR YEAR 1904
1904 RUN-OFF OF OWENS VALLEY, NORMAL
UNIFORM DRAFT OF 422 SEC. FT.
SECOND FEET
1200
1100
1000
900
800
700
600
500
400
300
200
100
JAN 1904
JAN. 21
FEB. 10
MAR. 1
MAR. 21
APR. 10
APR. 30
MAY 20
JUN. 9
JUN. 29
JUL. 19
AUG. 8
AUG. 28
SEP. 17
OCT. 7
OCT. 27
NOV. 16
DEC. 6
DEC. 26
CASE 2
Discharge of Owens River at Charlies Butte combined with the discharge of streams draining the East slope of the Sierra Nevada Mts. below the Conduit Heading, namely Tinnemaha Creek to Ash Creek, inclusive. The maximum safe draft as a continuous flow of 400 sec. ft which corrected for evap. loss, gives a net flow of 378 sec. ft. The construction of the Long Valley Reservoir or pumping plants of sufficient capacity will make possible a draft of 422 sec. ft. which corrected for evap. loss, gives a net flow of 400 sec. ft. available for domestic consumption etc. The conduit capacity required for the latter draft from Haiwee to the Fernando Reservoirs is 410 ft.

cisquito Canyon. This tunnel will have a capacity of 1,000 cubic feet per second. Below this point it is proposed to install the power plant for the system.‡

The demand for power varies with the days of the week and the hours of the day. The load factor, as it is called, is the ratio between the average continuous consumption of power and the maximum demand, which maximum usually occurs in the winter time between 5 and 6 o'clock in the evening. At this time power is needed for both lighting and manufacturing. If a power plant can be designed so that its output can vary with this fluctuation in demand, its efficiency is correspondingly increased. In and around Los Angeles this load factor is approximately 32 per cent. The capacity of the conduit below the Fairmont Reservoir site to the power plant will be 1,000 cubic feet per second. This phase of the situation is fully discussed in the report of the Board of Consulting Engineers. From the South end of the Elizabeth Lake tunnel to the point of diversion from the San Francisquito Canyon below, the fall is 1,500 cubic feet. At first the water will be liberated from this tunnel and allowed to flow down the natural channel of the canyon to the point of diversion. Therefore, as far as the aqueduct proper is concerned, there will be no construction expense in getting the water through the heart of the Coast Range after the tunnel at the crest is passed. This obviates a great expense. A small regulating reservoir will be constructed in the San Francisquito Canyon at this proposed point of lower diversion sufficient to regulate the hourly fluctuation from the power house. From this diversion point to the San Fernando Valley the aqueduct will have a capacity of 410 cubic feet per second.

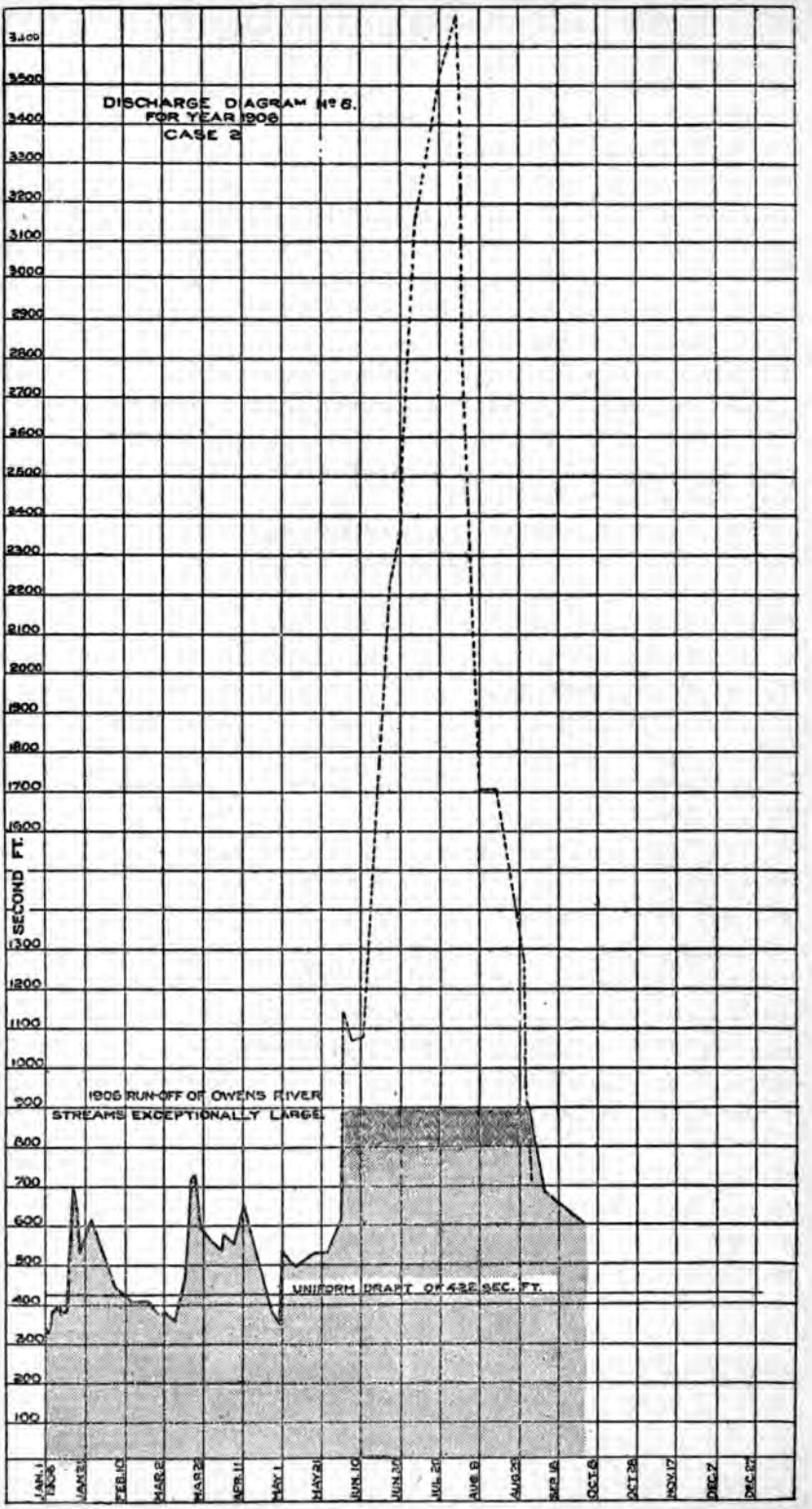
In the San Fernando Valley the water will be discharged into two reservoir sites. The City controls the greater portion of the land in these two sites. Their combined capacity is 36,600 acre-feet or enough to furnish a full supply from the reservoirs for a month and a half in case of breaks in the line above, or 50 second feet per year. The great value, however, of these reservoir sites, is that they will permit of accumulating water during the winter time in the San Fernando Valley and holding it for use during the following summer. The normal mid-summer use in Southern California is naturally from two to three times the normal winter consumption. These reservoirs are of such capacity that an aqueduct discharging 400 cubic feet per second or 20,000 inches for 12 months *into* them may have its flow so regulated that the discharge *therefrom* may be 500 cubic feet per

‡See Profile and Map Plate I.


DISCHARGE DIAGRAM Nº4.
FOR YEAR 1905
CASE 2.
1905 RUN-OFF OF OWENS VALLEY STREAMS, VERY LIGHT
UNIFORM DRAFT OF 422 SEC. FT.
SECOND FEET
900
800
700
600
500
400
300
200
100
0
JAN. 21
FEB. 10
MAR. 2
MAR. 22
APR. 11
MAY 1
MAY 21
JUNE 10
JUNE 30
JUL. 20
AUG. 8
AUG. 28
SEPT. 18
OCT. 8
OCT. 28
NOV. 17
DEC. 7
DEC. 27

second or 25,000 miner's inches during six summer months, and 300 second feet or 15,000 miner's inches during the winter months. This practically permits of furnishing 25,000 miner's inches with an aqueduct capacity of 20,000 miner's inches. This system of storage regulation must be kept fully in mind in determining what the available water supply for the City is from the Owens Valley. There is a great fluctuation in the flow of the Owens River but it is not subject to violent floods such as occur in Southern California. The statement is untrue that the Owens River goes dry at the point of diversion proposed by the City. No public records show this and as far as known no Reclamation Service Engineer has ever made this statement. During the May, June and July floods caused by the melting of the snow there are large volumes of water which, when regulated through reservoirs will permit of delivering a continuous flow such as is described below. These flood waves are now passing into Owens Lake and wasted. In addition the irrigation season in the Owens Valley is not over five months in duration each year. During the remaining seven months the elevation of the Valley being 4000 feet and cold, irrigation is not feasible. Therefore for seven-twelfths of the year the water rights which the City has not purchased are not used, beneficially at least, by the irrigators. It is not possible to make an absolute statement of the amount of water which a stream will yield under varying future conditions, or even as to the volume, exact legal rights for which the City has in the Owens Valley. There is given below, however, a statement which is as accurate as can be made from an engineering standpoint. It is not the province of your engineer to determine what the legal rights are.

For a period of eleven years Mr. J. B. Lippincott was in charge of all the stream measurements and studies of hydrographic data in the State of California for the United States Geological Survey. He has given the question of available water supply from the Owens Valley careful study in collaboration with Mr. Charles H. Lee, whose report is given as Appendix D. in full. Mr. Lee was an hydrographer in the United States Geological Survey and resigned from that organization to accept a position with the City of Los Angeles. He was detailed to study these hydrographic conditions and his report is believed to be accurate and his conclusions reasonable. Mr. James D. Schuyler of the Board of Engineers, was, between 1878 and 1885, connected with the California State Engineering Department and detailed to the study of California streams. Mr. John R. Freeman of the same Board has also made careful study of this subject in California prior to


DISCHARGE DIAGRAM No 8.
FOR YEAR 1908
CASE 2
SECOND FT.
1908 RUN-OFF OF OWENS RIVER
STREAMS EXCEPTIONALLY LARGE
UNIFORM DRAFT OF 432 SEC. FT.
JAN. 1 1908
JAN 31
FEB 10
MAR 2
MAR 22
APR 11
MAY 1
MAY 21
JUN 10
JUN 30
JUL 20
AUG 9
AUG 29
SEP 18
OCT 8
OCT 28
NOV 17
DEC 7
DEC 27

his work for the City of Los Angeles. This Board of Engineers reports:*

"After a study of all these measurements, and of the computations which have been made, we are in agreement with the report submitted to us by the engineers of the Los Angeles Aqueduct that 410 cubic feet per second of water can be depended upon with the regulation of the Haiwee Reservoir alone in years similar to those in which measurements have been made upon the Owens River, and that with the further aid of the Long Valley reservoir the 410 cubic feet per second of water can be depended upon in years as dry as any that have occurred upon the adjoining watersheds in the past sixteen years.

"We have not thought it necessary to attempt to determine just how much water has already been acquired by the City of Los Angeles, but from the information given us, it is plainly a large proportion of the quantity above named and sufficient for all probable needs for several years after the completion of the aqueduct. Moreover, it is expected that additional water-rights will be obtained before the completion of the aqueduct."

The City has acquired, by purchase, water rights aggregating about 15,000 inches, based upon appropriations by its predecessors on the river and tributary streams. These rights are for the use of water during the irrigating season, and from careful measurements will yield, during such seasons, to the City a continuous flow during normal years, of about 11,000 inches. In addition to these rights, the City has acquired practically the entire river frontage from the intake to Owens Lake, a distance of nearly fifty miles. As riparian owner of all of such lands, the City would have the right to divert winter waters which flow during the non-irrigating season, and also the right to regulate the flood waters through its reservoir system below the point of intake. Combining these summer irrigation waters with the winter flow, and by so regulating the flood waters, the City would receive during normal years, a mean annual flow of from 15,000 to 20,000 inches. With 240,000 acre feet storage at Long Valley, the net supply that may be delivered in all years from these rights is estimated at 400 second feet or 20,000 inches.

In 1898 Kings River flowed but 46 per cent of a 16 year mean. This was a most unusual record, the next lowest year being a 71 per cent year; making a ratio between 1905 and 1898 would indicate the total output from the valley for the year 1898 of 278 second feet, showing a deficit of 144 second feet. This indicates the necessity ulti-

*The Report of the Board of Engineers is given in full as Appendix E.

mately for the construction of the Long Valley Reservoir site for an annual hold over to meet such a contingency, provided we should endeavor on such extreme cases to deliver a full supply. Deficits of this sort have been met on more than one occasion under many of the water systems of Southern California, without vital loss. The conditions during such a year may be met partially by pumping from the gravel beds in Owens Valley.

Mr. Lee concludes his hydrographic study as follows:

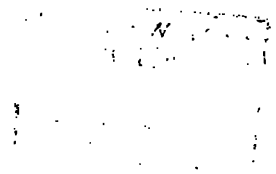
"The complete system of reservoirs and conduits which is to be known as the Los Angeles Aqueduct will consist of (1) the Long Valley Reservoir at the head of the Owens Valley with a 140 foot dam, (2) the channel of the Owens River to Charley's Butte, (3) sixty miles of canal and conduit of capacity varying from 700 to 900 second feet, (4) Haiwee Reservoir with a 75 foot dam at the lower end, (5) 140 miles of conduit of 410 second feet capacity, (6) Fernando Reservoir No. 1, of 15,940 acre-feet capacity with a 120 foot dam, (7) Fernando Reservoir No. 2 of 20,660 acre-feet capacity with a 130 foot dam. "The supply will consist of the Owens River at Charley's Butte as regulated by the Long Valley Reservoir plus that of all springs and streams from Taboose to Ash Creeks* inclusive, or its equivalent. This system will be adequate to deliver from the lower end of Fernando Reservoirs a continuous flow of 400 second feet under the most adverse conditions with the possible exception of a dry period of two or more consecutive years, which may occur once in fifty years."

QUALITY OF THE OWENS VALLEY WATER.

The Board of Engineers finds that "the Owens River water is much softer than the water now supplied to the City, which contains from two to three times as much dissolved mineral matter as the waters of Owens River. Our examination of the streams in the Owens Valley showed that the creeks coming from the Sierras furnished water which is clear, colorless and attractive; the water in the river being made up of the combined flow of these creeks is of similar character, but has a slight turbidity and stain owing apparently to drainage from the marshes in Long Valley and to other return water from the canals and irrigated lands. This feature would make the water somewhat objectionable if it were to flow directly from the river into the City pipes; and it has little or no significance in the present instance where the

*Tributaries entering below Charley's Butte

OWENS RIVER AT POINT OF DIVERSION
For the L. A. Aqueduct



water, after being taken from the river, is to be held for a long time in a large storage reservoir where the particles which produce the turbidity will have time to settle. The long period of storage in the reservoir will also be an important safeguard against the transmission of disease germs should any enter the water of the river, because it has been found, both by experiment and experience, that disease germs are all or nearly all destroyed, where the water is held sufficiently long in the reservoirs."

LAND AND WATER PURCHASES.

Under the heading of historical sketch, the method of procedure in acquiring rights in the Owens Valley was referred to. The effort has been made on the part of the City to purchase all lands riparian to the Owens River from the north line of Township 10 South, Range 34 East, M. D. M. (which is ten miles north of the proposed point of diversion) to Owens Lake. The City has also filed under the state law on all surplus water in Owens River at the diversion point and on all tributaries south of the diversion point, as well as on the main river at the Long Valley reservoir site. The California court's rulings as to the relative rights of apropriators of water, as against lower riparian owners, are not entirely clear, consequently the purchase of these lower riparian lands was considered desirable. With very minor exceptions the City now owns all of the riparian lands on both banks of the Owens River from the diversion point to the Owens Lake, and Owens Lake has no outlet and is saline. Purchases have also been made of lands riparian to the tributary streams entering the valley from the diversion point south and also of lands having water rights on these tributary streams.

A large map has been prepared, showing all lands owned by the City of Los Angeles in the Owens Valley. This map is too large to be included in this report. It is, however, an official document and may be inspected at the office of the Chief Engineer. The largest of all the purchases that have been made is that of the Rickey Ranch, which extends from Big Pine in a fragmentary way as far south as Independence. The City has acquired 22,670 acres by this purchase, and the Long Valley reservoir site.

A purchase was made from Mr. Charles A. Collins of 4,720 acres of land, including a two-thirds interest in the irrigation canal known as the A. O. Collins Ditch. This purchase included 275 inches of water in the Dell Ditch, and also the Warm Springs, which carries a water right of about 100 inches. The price of this property was $80,000. Measurements by the United States Geological Survey, during the

year 1904, show a maximum discharge of the A. O. Collins canal of 43.1 cubic feet per second, or 2155 miner's inches. The total area of the lands purchased in the Owens Valley to date, including the Long Valley reservoir site, is 70,951 acres. The following additional purchases were made:

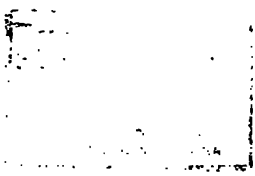
Swartout Reservoir	2040 acres.
Fernando Reservoir	198 acres.
Fairmont Reservoir	10 acres.
Tehachapi cement lands	3382 acres.

The grand total area of all lands purchased and contracted for is 76,581 acres, at a total cost of $1,140,000 in round numbers for land and water rights, including deferred payments not yet due, or at the rate of $14.89 per acre. Appendix F gives a list of all lands purchased.

On July 15, 1903, the Secretary of the Interior, acting under the terms of the Reclamation Act, withdrew under the first form of withdrawal, all public lands along Owens River in Mono County, from Long Valley to Round Valley. This includes all public lands in the Long Valley Reservoir site, and along the canyon of the Owens River, where a 3,000 foot fall occurs in the stream. Under this form of withdrawal, no public lands can be taken up in any manner except by special permission of the Secretary of the Interior. This was done in order to protect for the Reclamation Service the Long Valley Reservoir site, and to prevent power developments on the river below the reservoir site in such a way as might interfere with the utilization of that site by the Government. On August 10th and August 20th, 1903, the Secretary withdrew under the second form of withdrawal, all public lands in the Owens Valley from a point south of the lake to the Mono County line. Under this form of withdrawal, public lands cannot be taken up except under the Homestead Act, or under certain special permits granted by the Secretary of the Interior. These withdrawals are still in force, but these lands will probably be restored to the public domain when the Secretary decides to withdraw formally from the Owens Valley Project. These withdrawals have been of great value to the City of Los Angeles, in that they have largely prevented during the last four years, the extension of private holdings in the Valley, or the taking up of public lands in the Long Valley Reservoir site.

Under the Act of Congress of June 30, 1906, granting rights of way to the City of Los Angeles (See Appendix C), provision is made for the purchase of public lands in reservoir sites in the Owens Valley, the City being given the preference in these purchases, subject to valid existing rights.

ROCK CREEK—NOVEMBER 1906.
This is one of the numerous tributaries of Owens River. Note the ice.



Acting largely on the request of the City of Los Angeles, Mr. Gifford Pinchot, Chief of the Forestry Bureau, has extended the boundaries of the Sierra Forest Reserve well down into the Owens Valley from the west and so as to include the greater portion of the drainage basin above Bishop. This forest reserve will permanently prevent the taking up of public lands therein in this district. These forest reserve boundaries have also been temporarily extended so as to include all of the drainage basin of Owens River north of Owens Valley, and also all the lands in the Owens Valley from Big Pine to the Haiwee Reservoir site. The City has requested this extension because when the restorations are made by the Secretary of the Interior of lands with drawn under the Reclamation Act, the City could not prevent filings on these lands by individuals, and as there is a great deal of public land in the Owens Valley, this would lead to annoyance and expense to the City, particularly in connection with the filings that might be made on the lands riparian to the tributary streams. The extension of the forest reserve boundaries will conserve both the quality and the quantity of water available from the reserve. The Bureau of Forestry throughout the entire period when the city was considering this project, has repeatedly aided the City in this enterprise.

In order to further aid the City, President Roosevelt, by an Executive order, has withdrawn all public lands along the Owens River and along the line of the aqueduct which would be of particular strategic importance to the City, pending the time when the City could file its Right of Way maps as required by law and the regulations of the Department. The purpose of this was to prevent speculators from filing on lands which would be of importance to the City in its enterprise. The total area ordered withdrawn by the President amounted to 298,880 acres. As our surveys have progressed, it has been found that certain of these lands were not essential, and the City has suggested the restoration of 55,680 acres. There still remain withdrawn by Executive order for the benefit of the City, 243,200 acres. Under the Act of Congress of June 30, 1906, providing for the acquiring of rights of way over public lands by the City, provision is made for the filing of certain rights of way maps within two years from the time of the passage of the Act. On January 25th, 1907, the first Right of Way application was filed with the U. S. Land Office by the City of Los Angeles. This specifically covers all public lands on the right of way from the point of diversion to the San Fernando Valley.

The Southern Pacific Railroad Company, through its land grants, either owns or claims alternate sections of land extending from a point near Freeman, practically through to the San Fernando Valley, or over

100 miles of the route. Negotiations have been conducted with the Railroad Company for obtaining rights of way over these railroad lands, and assurances have been received from railroad officials having proper jurisdiction, that these lands for right of way purposes will be sold to the City at the rate of $5.00 per acre. A preliminary deposit has been made of $500.00 as evidence of good faith on the part of the City in making its application. Approximately 1,000 acres will be involved in these right of way purchases.

ORGANIZATION OF WORK.

The Board of Public Works assumed office on March 1st, 1906. Prior to that time the administration of the affairs of the Los Angeles Aqueduct was conducted by the Board of Water Commissioners. Under the conditions of the revised Charter, the Water Board has jurisdiction over the Water Works as built and over funds derived from water rates. They also have general authority to purchase lands and water rights, and to make extensions and betterments. The Board of Public Works, however, has charge of all expenditures of money derived from the sale of municipal bonds, and as the Los Angeles Aqueduct is to be built from the sale of bonds, the Board of Public Works becomes the official governing body. However, because of the great public confidence in the Board of Water Commissioners, and their knowledge of the subject involved, the Board of Public Works has always freely consulted and co-operated with the Water Commissioners, and all important actions involving the determination of general policy have been taken as the result of joint conferences of these two Boards. An Advisory Committee has been appointed by these two Boards to handle the details of current affairs as they present themselves. This Advisory Committee consists of the president of the Board of Public Works, president of the Water Board, the chief engineer, the principal assistant engineer of the Aqueduct, and the attorney for the Aqueduct. This Committee holds sessions on Tuesday and Thursday of each week at their office in the Union Trust Building. They only make recommendations to the Board of Public Works. The action of the Board of Public Works is necessary.

The Charter places the appointing power, as well as the contracting power, in the hands of the Board of Public Works, but the selection of men to fill positions on the Aqueduct is through the Civil Service Commission, with the exception of a Disbursing Agent, who is exempted under the provisions of the Charter. The Charter, as amended on February 7, 1907, provides for the creation of the position of Disbursing Agent, and the payment by him of duly authorized bills out-

side of the City. The Board of Public Works has the right to enter into contracts and order bills paid. Provision is furthermore made for exemptions from the Civil Service rules, of such positions as are recommended by the Board of Public Works, approved by the Council and by the Civil Service Commission. Up to the present time, March 15, 1907, no other exemptions have been made, although certain exemptions have been requested by the Board of Public Works. Appendix G is a definition of the powers of the Board of Public Works by the City Attorney.

The Chief Engineer of the Aqueduct, Mr. William Mulholland, is also the superintendent, engineer and manager of the Los Angeles City Water Works. Mr. Mulholland has been employed by the Los Angeles City Water Works since the year 1878. He assumes his new duties, therefore ,with a training and knowledge of his position gained from twenty-eight years' service with that Department.

The Attorney for the Aqueduct, Mr. W. B. Mathews, served as City Attorney for three terms, from 1900 to 1906, inclusive. He had no opposition for his last election. Dillon & Hubbard, Attorneys, New York City, who are the leading experts in legal matters relative to municipal bonds, are engaged as counselors of the Aqueduct. The Accounting Department has been placed under the charge of Mr. W. M. Nelson. This Department is considered of great importance, not only in auditing and inspecting the accounts originally, but also in keeping records of the cost of various units of the work. Mr. Nelson was an "auditor of disbursements" with the Southern Pacific Company. In this capacity his duty was to originate and check construction accounts throughout the system, and particularly to initiate systems of accounts for affiliated enterprises. Mr. Nelson came to the service of the Aqueduct with high recommendations from his superior officers in the Southern Pacific Company. His services were sought by the City. Mr. George Bugbee, who was auditor for the construction of the Harriman lines in Mexico, was engaged in an advisory capacity to assist in the installation of the system. The accounting system that has been adopted is the one used by the Harriman railroad systems and ten other railroad companies in the United States, and has been lately adopted by the Panama Canal Commission. Wherever an article is subject to competition, bids are obtained. The system of accounting is complete, and is in no sense an experiment.

At present there are three fully equipped locating parties engaged in surveying the route of the Aqueduct—one party engaged in railroad surveys, and an office force maintained at 1109 Union Trust Building. A commissary department has been started at Mojave, where

a stock of supplies is kept, upon which requisitions are drawn by the field parties. A construction camp is maintained in the Owens Valley, at work on the main canal. The cement quarries are being opened. The disbursing department has not yet been organized. Bills are being paid through the City Auditor and the City Treasurer.

SURVEYS.

A line of precise levels is being run from Los Angeles to the intake, with an instrument such as is used by the Coast Survey and the Geological Survey on this class of work. This work is being done by Charles H. Lee, who was first detailed to spend several days with one of these Government precise level parties. Permanent iron bench marks will be set along the line of the Aqueduct. A preliminary angle transit line with Wye levels has been run from the point of diversion on the Owens River along the line of the Aqueduct by way of Mojave, to the eastern end of Antelope Valley at Palmdale, and thence via two long tunnels to the Tujunga. Another line has been run from a junction with the first line south of Fairmont, near Elizabeth Lake, via San Francisquito to Fernando. This latter line shortens the length of aqueduct some twenty miles, and very materially reduces the cost of the work. Instead of two six-mile tunnels through the range near Acton, we now have one tunnel five miles in length near Elizabeth Lake, with the opportunities for a shaft to be put down to grade midway. Many trial routes have been run for the rougher portions of the lines. Detail topography has been taken for the entire line, and excavation quantities have been computed therefrom. Land lines in many instances have been restored and connected with for rights of way.

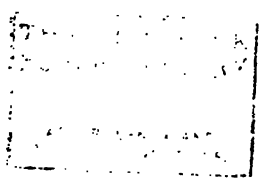
The Board of Engineers, in preparing their estimate, used the route by way of Elizabeth Lake.

The aggregate length of theAqueduct , as estimated by the Board of Engineers, is summarized as follows:

	Miles.	Per Cent.
Conduit, unlined canal	22.20	9.9
Conduit, lined with rubble masonry or concrete	164.23	72.7
Tunnels, in rock	18.24	8.1
Tunnels, in earth	10.11	4.5
Siphons of steel pipe, crossing canyons	8.99	4.0
Steel flumes, crossing shallow and narrow depressions	1.80	0.8
Total	225.87	100.0

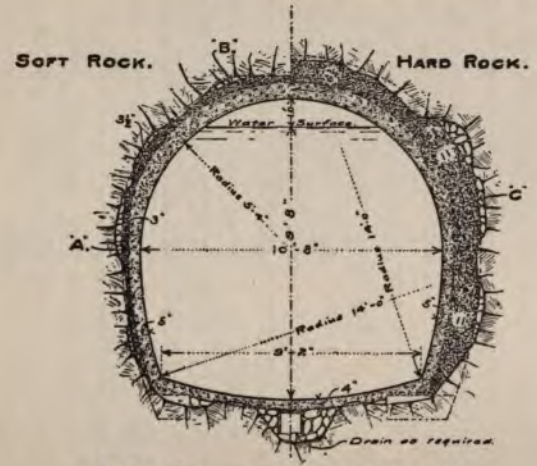
THE JAWBONE CANYON

This must be crossed with a pressure pipe. It is the most expensive and hardest piece of work on the line.

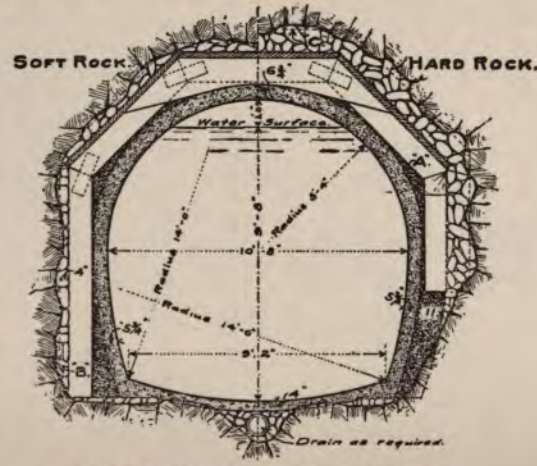


TYPICAL SECTION.

ELIZABETH LAKE TUNNEL.



TYPE "A" - UNTIMBERED ROCK.



TYPE "B" - TIMBERED ROCK.

Capacity 1000 second feet
Hydraulic Slope 2¼ feet per 1000 ft.
Coefficient of roughness .014

SCALE OF FEET

NOTE:
Line "A" denotes Outside Line of Concrete.
" "B" " " " " Soft Rock Excavation.
" "C" " " " " Hard " "

The total number of miles of line surveyed to date is 709. Topographic survey has been made of the Haiwee reservoir and dam site, of the Fairmont Reservoir, of the Llano Verde Reservoir, and of four reservoir sites in the San Fernando Valley. Surveys have also been made for the installation of a power plant on Division Creek.

The Board of Engineers recommended modifications in the grade from the Haiwee Reservoir site to the Fairmont Reservoir site. This calls for a resurvey of the line between these two points, a total distance of 146 miles. These changes were made because the Board was opposed to the construction of steel pressure pipes across ravines or depressions, where they could be avoided. The change in elevation resulting will vary from a few feet to a maximum of 100 feet at Fairmont. The engineering parties are now engaged in these surveys, of which 55 per cent. had been completed on March 1. Changes in the line will undoubtedly continue as the knowledge of the country increases, until the actual construction work begins. It was not until after the Board of Consulting Engineres had arrived on the ground, that surveys of the entire line were connected, so as to permit of a comprehensive study of the line as a unit, hence the extensive modifications in grade that were adopted. Further material improvements, looking towards the shortening of the line and the cheapening of the work, will be made. The length of the line probably will be reduced ten miles from the figures used by the Board of Engineers.

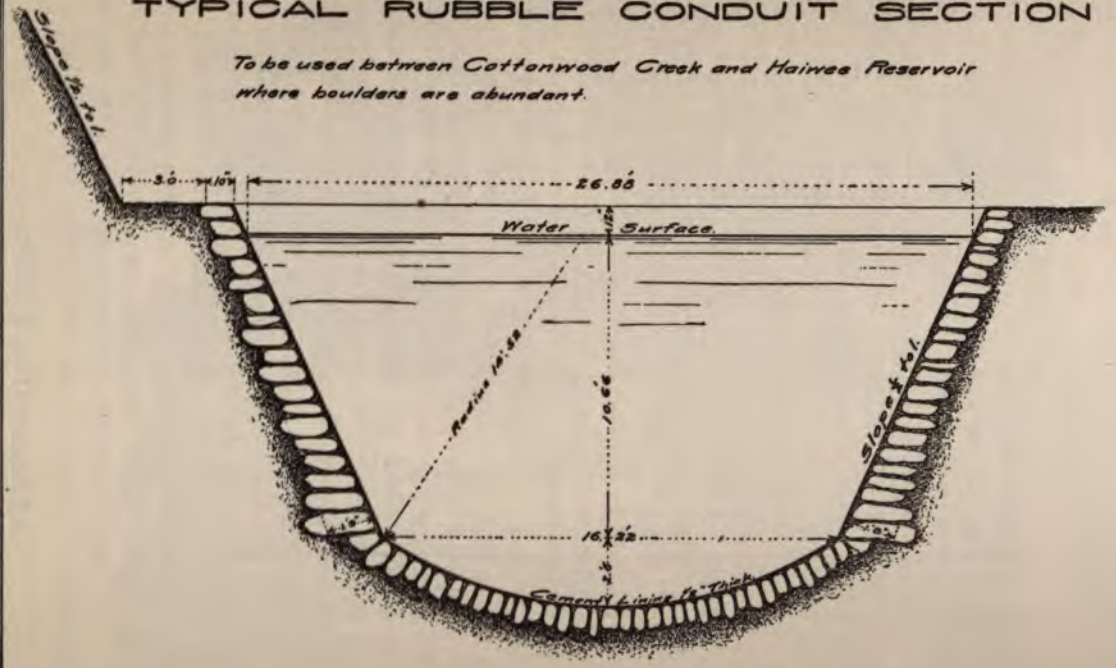
CONSTRUCTION.

About $1,000. a month has been spent on construction work in the Owens Valley during the last eight months. The main canal has been opened for a distance of five miles, and partially graded, 66,084 cubic yards of earth having been moved to date. About six miles of wagon road have been built along the proposed line of the Aqueduct, on the west shore of Owens Lake. Arrangements are being made to install a power plant on Division Creek in the Owens Valley, for the purpose of obtaining electric energy for construction work. A right of way map has been filed with the United States Land Office for this power plant. Bids have been received for the installation of a pressure pipe, 5100 feet long, to develop 400 feet of head. Bids are now being called for the hydro-electric machinery for the power plant. They will be opened on March 15, 1907. Plans have been prepared for the erection of a hydraulic dredge, to be used in building the first twenty miles of conduit from the diversion point to the Alabama Hills. The total estimated cost of this power plant and dredge is $26,120. A crew of

ROAD BUILDING BY THE CITY ALONG THE LINE OF THE AQUEDUCT,
and Owens Lake in the background on the right.

TYPICAL RUBBLE CONDUIT SECTION

To be used between Cottonwood Creek and Haines Reservoir where boulders are abundant.



Capacity 900 second feet.
Coefficient of roughness = .018
Slope = .00016

SCALE OF FEET.
0 1 2 3 4 5 6

miners have been employed and are at work opening up the limestone quarries for the cement plant at Tehachepi.

RAILROAD SURVEY.

The railroad situation has been studied. A preliminary survey has been made over the difficult portion of the line, from the mouth of Jawbone Canyon over the Red Rock summit, and a three per cent. grade has been located. Mr. T. B. Downer, a railroad engineer of experience, has been assigned to this work. The estimates clearly indicate that there will be marked economy in building a railroad for the purpose of hauling freight for the Aqueduct. Moreover, it is doubtful whether a sufficient number of animals could be obtained to freight the material that is required for construction by wagon.* The figures indicate that a construction road can be built on or near the line of the Aqueduct—using light rails and rolling stock, material handled over the road, and after the construction, the road torn up and sold for second-hand junk, operating and fixed charges being paid—for a cost of ten cents per ton mile of freight handled. The wagon freight would amount to about twenty cents per ton mile. The total number of ton miles to be handled is estimated at approximately fourteen millions, from the west end of Antelope Valley to the southern end of Owens Lake. We wish to avoid the construction of this railroad by the City for the following reasons:

First, in order to avoid the additional amount of work requisite for the construction and operation of the road; second, it is believed that an organized railroad corporation, actively engaged in railroad work, can build this road more quickly and economically than the City could; third, the City Charter would not permit of the municipality entering into a general transportation business, outside of the hauling of City material and equipment for construction purposes, and as there is a large area of agricultural and mining country in the Owens Valley and easterly thereof, in the desert region, which should naturally have its outlet to Los Angeles, it would be to the interests of this City to have a railroad company in the commercial transportation business build this line, so that Los Angeles may enjoy the benefits of this trade. At present Owens Valley and the surrounding regions are almost undeveloped because of very defective transportation facilities; the freight therefrom going by a circuitous route over a narrow gauge railroad, over two summits 7,000 feet high, to San Francisco, a distance of 600 miles. If it came townards Los Angeles, the distance to a market would be reduced to 230 miles, with a down-hill haul.

*Appendix H gives a study of the transportation situation by W. S. Post.

CLAY CLIFFS IN RED ROCK CANYON
on the line of the proposed Aqueduct.

Because of these conditions, negotiations have been taken up with the Santa Fe and Southern Pacific Railroad Companies, both of which enter Mojave, suggesting that they construct the road with a view of handling the traffic that the aqueduct would have to offer. Full report of these negotiations has been made to the Board of Public Works by the chief engineer.

Negotiations have also been taken up with both the Santa Fe and Southern Pacific Companies, requesting that special freight rates should be given to the City of Los Angeles for the Aqueduct work, similar to the concessions granted to the Reclamation Service for the construction of Federal irrigation projects. It is permissible under Federal laws that such special rates be given to municipalities. Very satisfactory progress has been made in these negotiations. The California Legislature passed an Act in March, 1907, authorizing any incorporated city to construct and operate any works, railroad, power plant or other necessary works for the preparation, manufacturing, handling or transporting of material or supplies required in the construction of any public work, and to acquire by purchase or condemnation, lands or other necessary property for said purposes. This Act is given as Appendix M.

CEMENT MILL.

Application was made by the Chief Engineer to the Secretary of the Interior, requesting that Mr. E. Duryee, cement expert of the Reclamation Service, be detailed to study the cement investigation along the Aqueduct. The Secretary permitted Mr. Duryee to devote one-half of his time to the City of Los Angeles, and arrangements of this nature were entered into with Mr. Duryee last October. Lime and clay deposits were found near Mojave. The Cuddeback Ranch, containing 3000 acres, upon which the clay is found, has been purchased. Options have been secured upon the limestone. Mr. Duryee's report on the cement situation is given as Appendix I. He estimates that the cement mill can be constructed for $302,363, exclusive of the price of the land. The Board of Engineers estimated that 1,300,000 barrels of cement will be required. The cost of the mill, distributed over the output of cement, is 23 cents per barrel. The cost of the mill has been considered separately by the Board of Engineers. Mr. Duryee estimates that the cost per barrel for the manufacture of the cement, exclusive of the cost of the plant, will be $1.00; the capacity of the mill to be 1000 barrels per day.

The materials have not only been tested chemically, but a small kiln has been erected in Los Angeles, and a burn of the materials made.

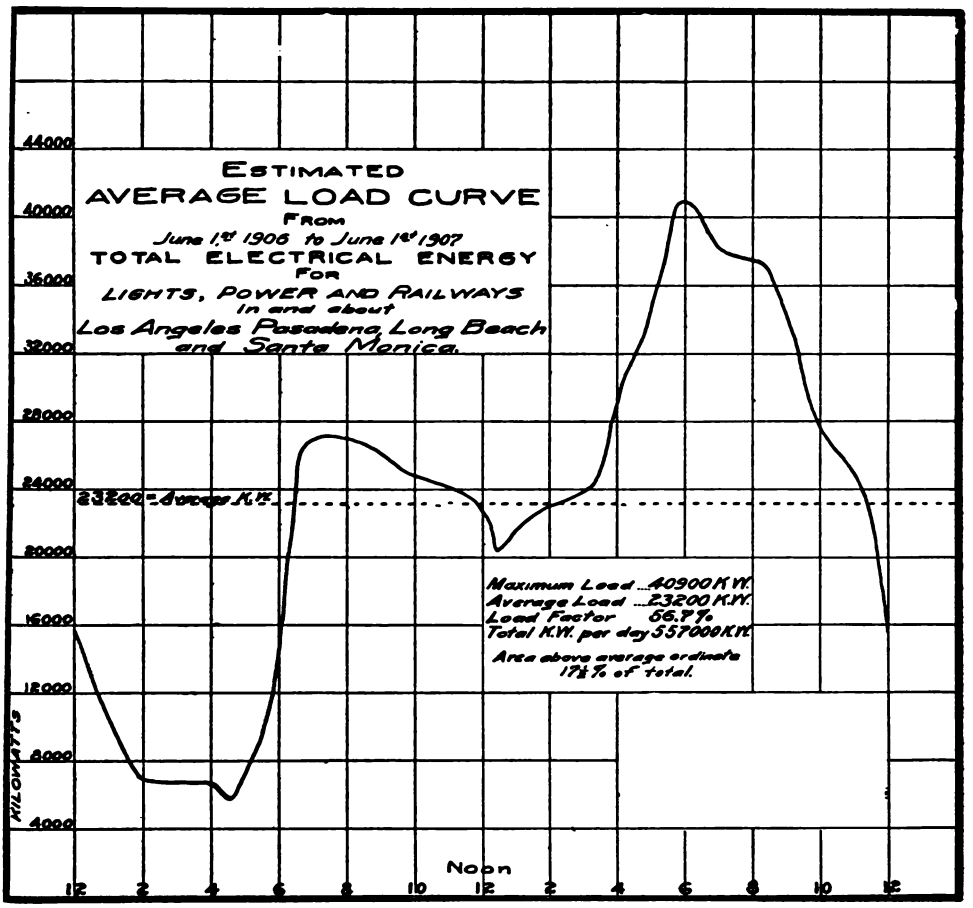
A 28-day test shows a breaking strength of the neat cement of 870 pounds, and with a mixture of one of cement to three of sand, of 550 pounds. The results of the tests have been satisfactory and have demonstrated that superior Portland cement can be made with the materials available. Mr. Duryee finds that the location is admirably suited to the manufacture and delivery of cement midway of the conduit line. The City will not exhaust the deposit of clay and limestone, and it is thought that the plant at the end of the construction will be worth almost as much as it cost the City.

POWER PLANTS.

Particular reference is made to the portion of the Report of the Board of Engineers relative to the development of water power. The most important site is in the San Francisquito Canyon, about forty-five miles from the City of Los Angeles. A total drop of nearly 1500 feet is available at this point. Another minor site for power development may be found a short distance below the end of the Aqueduct, in the San Fernando Valley. Another opportunity for power development occurs near Little Lake, 150 miles northerly from Los Angeles, where a fall of 270 feet can be obtained. The average continuous output of power with a complete water supply from these plants is estimated by the Board of Engineers at 49,000 H. P. The Fairmont Reservoir site at the intake of the main plant will permit of the water being liberated for this power as the demand occurs in the City. The water may be conserved for this purpose during legal holidays and nights, and liberated during working hours in such a way as to meet the demands. This the Board estimates will permit the City to enter into contracts for a total output of 93,000 H. P., measured at the point of delivery in hours of greatest demand.

The Board finds that the conditions for the economic development and maintenance of power are very favorable, and its safety against interruption or diminution by drouth, and the permanent character of the aqueduct, tend to make the power development feature particularly attractive and valuable. Mr. E. F. Scattergood, an electrical engineer of extended experience in the construction of hydro-electric power plants in Southern California, has made a detailed estimate on the cost of installing the power plants, and his report is attached as Appendix J.

The proposed plan is to build the Aqueduct for the purpose of supplying water for municipal purposes, and after its completion, if the citizens of Los Angeles consider it desirable to install these power plants, they may subsequently be built as independent works. The


ESTIMATED
AVERAGE LOAD CURVE
FROM
June 1st 1906 to June 1st 1907
TOTAL ELECTRICAL ENERGY
FOR
LIGHTS, POWER AND RAILWAYS
In and about
Los Angeles Pasadena Long Beach
and Santa Monica.
23200 = Average K.W.
Maximum Load ... 40900 K.W.
Average Load ... 23200 K.W.
Load Factor 56.7%
Total K.W. per day 557000 K.W.
Area above average ordinate
17½% of total.
KILOWATTS
44000
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
12
2
4
6
8
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Noon
12
2
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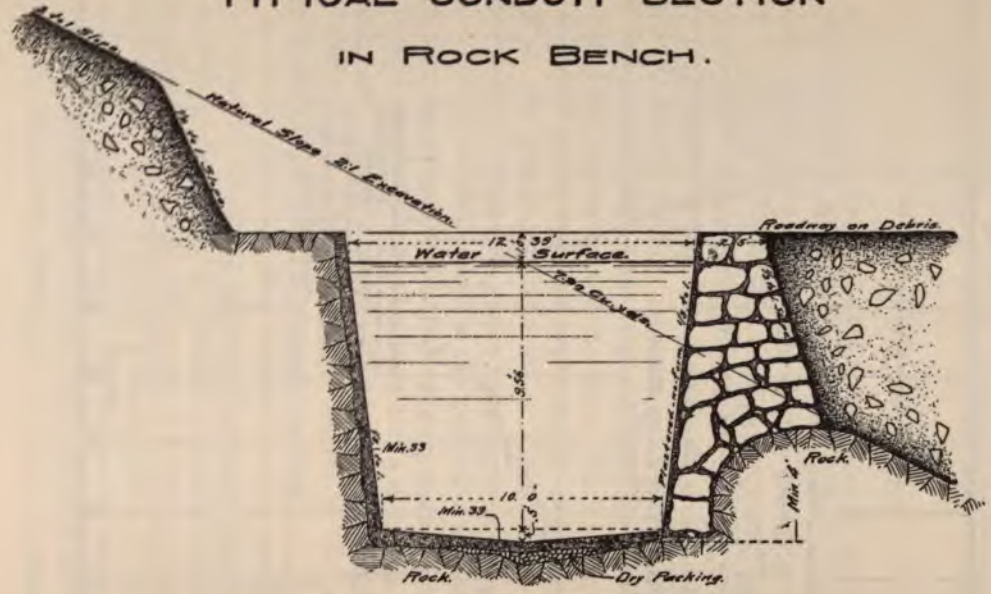
12

TYPICAL CONDUIT SECTION

IN ROCK BENCH.



Capacity 430 second feet.
Coefficient of roughness = .018

SCALE OF FEET.

0 1 2 3 4 5 6

installation of power has not been included in the Aqueduct estimates, because the power situation is considered as wholly independent of the proposition of supplying water, and should stand on its own merits.

BOARD OF ENGINEERS.

At the time the preliminary bond issue for $1,500,000 was submitted to the people of Los Angeles in September, 1905, the Board of Water Commissioners promised to employ hydraulic engineers of national reputation to pass on the plans and cost of this project. In accordance with this agreement a Board of Engineers consisting of John R. Freeman, Frederic P. Stearns and James D. Schuyler were so employed. Mr. Stearns at that time was Chief Engineer of the Metropolitan Water Board, which has constructed and is now operating the water works for some twenty towns around Boston Bay. He was President of the American Society of Civil Engineers, Consulting Engineer of the Panama Canal, and Consulting Engineer on the additional water supply for the City of New York. Mr. John R. Freeman is a past President of the American Society of Mechanical Engineers, Consulting Engineer for the additional water supply of the City of New York, former Consulting Engineer for the Metropolitan Water Board, and lately appointed Consulting Engineer for the Panama Canal. It was considered particularly desirable to employ some Western Engineer who was familiar with the cost of work in the Southwest, and particularly with conditions in Southern California. Mr. J. D. Schuyler was Assistant State Engineer for California from 1878 to 1882. He built the Sweetwater and Hemet Dams, and has been connected as a consulting engineer with the construction of many important domestic and irrigation water works in arid America and in the Hawaiian Islands. He has been Vice-President of the American Society of Civil Engineers, and is a member of the Institute of Civil Engineers of London. He was engaged for the City of Los Angeles in practically all of the litigation during the last ten years relative to the acquisition of the Water Works for the City and for the protection of its water rights.

The appointment of this Board was the result of long deliberation, and their selection was made unanimously at a joint meeting of the City Council, Board of Water Commissioners, Board of Public Works, Merchants' and Manufacturers' Association, Municipal League and the Chamber of Commerce. Probably no stronger aggregation of hydraulic engineers was ever employed on the Pacific Coast. The Board convened in Los Angeles on November 14, 1906, and was contin-

uously engaged in reviewing this work until December 22. Prior to that time Mr. Schuyler made two trips over the line of the Aqueduct, and Mr. Freeman made one preliminary visit to the City. Eight days were spent by all on the examination of the line in the field, and the balance of the time was spent on plans and estimates.

They estimate the cost of the Aqueduct proper as $18,221,300. After adding for railway, cement plant and other accessories, including 15 per cent for contingencies, they reach a total of $23,110,700; and they further add, "for land and water rights, and for all legal and other expenses connected with their acquisition, from estimates presented by Messrs. Mulholland and Mathews, including what has already been expended, we add $1,375,000, making a total of $24,485,600.* They report the quality of the water satisfactory. The Board designed sections of the conduit on most conservative lines, and based their estimates thereon. Their estimate is given in detail in their report attached hereto as Appendix E. They estimate the time necessary for construction after the sale of the bonds as five years. No insurmountable engineering difficulties were found. The report concludes:

"We find the project admirable in conception and outline, and full of promise for the continued prosperity of the City of Los Angeles."

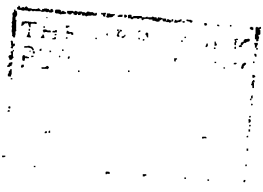
FINAL COMPLETION OF THE SYSTEM.

The Aqueduct as planned by the Board of Engineers with the water rights now owned by the City is adequate to deliver to Los Angeles a large proportion of the 400 second feet (20,000 miners' inches) above named, "sufficient for all probable needs for several years after the completion of the Aqueduct." It would be obviously unwise for the City at once to pile the cost of works that were not immediately necessary for the operation of the Aqueduct, on to the present cost of building the portion which is now essential. These additional works are left to be supplied as the demand for water approaches the total supply available. These extensions and betterments should be paid for from the earnings of the Aqueduct itself, in a similar way to the present policy of the City Water Department. The Board of Water Commissioners have abundantly demonstrated their ability to finance enterprises in this manner. During the year ending November 30, 1906, they added 46.68 miles of pipe lines to the water works system in Los Angeles, one large pumping plant, and one reservoir with a capacity of fifty million gallons, 5,968 new connections, 230 fire hydrants, 6,978 meters and

*This total is for all work and is inclusive of the $1,500,000 previously voted.

NEAR LITTLE LAKE.

The Aqueduct will pass from right to left near the center of the picture in a series of tunnels. This is one of the most difficult sections on the line.



sundry other betterments, paying for them from the water revenue fund and expending thus a total of $697,042.68 in one year.

The Aqueduct will be so constructed that it may be covered progressively as funds are available after its completion. The arguments that are so potent for the covering of aqueducts in the East on account of pollution, do not obtain with equal force in a desert region such as that traversed by the Los Angeles Aqueduct, which is practically devoid of human habitation and where little animal life is found. Sixteen and six-tenths per cent. of the total length of line is in tunnel and pipe line, and is therefore to be immediately covered. Below is given an estimate for covering the remaining portion of the Aqueduct from the Alabama Hills in the Owens Valley south to the Fernando Valley, and of building the Long Valley dam, the Fairmont dam and two dams in the San Fernando Valley. This will complete the Aqueduct.

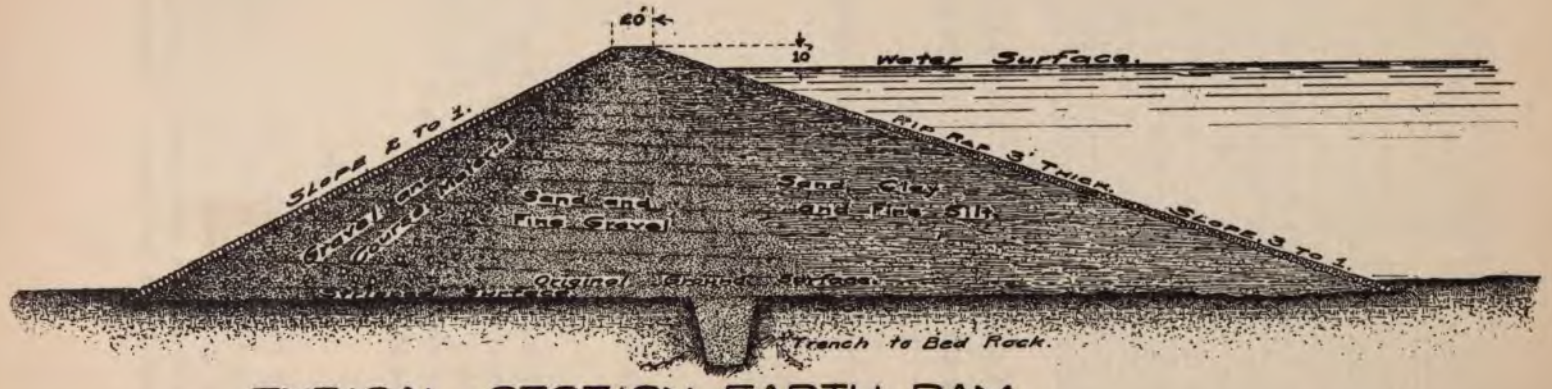
ESTIMATED COST OF BUILDING ADDITIONAL STORAGE RESERVOIRS AND COVERING THE AQUEDUCT.

Extra Cover from Alabama Hills, south 97.8 miles.	$1,180,000.
Fairmont Dam	150,000.
Fernando Dam No. 1	530,000.
Fernando Dam No. 2	360,000
Long Valley Dam	560,000.
	$2,780,000.
15 per cent for Engineering and Contingencies.	417,000.
Total	$3,197,000.

The installation of the power plants in the San Francisquito Canyon, including all necessary hydraulic and electrical work, for about 75 per cent. of the total power available from the complete Aqueduct, and its delivery at sub-stations in Los Angeles, is a separate matter, and is estimated upon as $4,494,000.

PIPE LINE.

The advisability of building a pipe line with a capacity of 5,000 inches from the Owens River to the City of Los Angeles has been suggested. Despite the fact that 6,978 meters were added to the water system in Los Angeles during the year 1906, the increase summer consumption was 154 miner's inches for that year. The percentage of con-



TYPICAL SECTION EARTH DAM.

HYDRAULIC FILL

nections metered increased from twenty to thirty-one during that period, so that, while there was a great addition to our population, the per capita daily consumption was reduced. The most wasteful consumers have now been metered, and the present per capita rate of 144 gallons daily may be considered as well-nigh the most economical use that may be expected. If our population continues to increase at the present rate of 30,000 annually, with a summer conusmption of 150 gallons per capita daily, this would call for an additional annual increment to our water supply of 350 inches. The necessity of our suburban towns is even greater than Los Angeles, and their growth is being retarded by their deficient water supply. It would be safe to assume that the demands in this entire area would be for 500 inches of water additional annually. At this rate, 5000 inches would be sufficient to meet the demands of this locality for a period of ten years. One of the controlling factors in the location of the Owens Valley Aqueduct is the difficulty of tunneling through the crest of the coast range north of Saugus, and on the south side of the Antelope Valley. The less the fall or grade of a conduit, the slower the velocity and consequent discharge. The larger the conduit with any fixed grade, the higher the velocity and discharge, provided other conditions are similar. From the intake until the crest of the Coast Range is passed, every possible saving in grade is made in locating the Aqueduct.

South from the crest of Elizabeth Lake to the San Fernando Valley, the fall is 1,700 feet, and here power will be developed. North of the summit, at Elizabeth Lake, the prevailing grade is about one foot per mile and seldom exceeds two and one-half feet per mile. The conduit is about fourteen feet wide and eight feet deep, and has a capacity of 430 second feet. A riveted steel pipe on these grades, having a capacity of 100 second feet (5,000 miner's inches), would vary from eight and one-half to six feet in diameter, and would cost about $21,800,000. The diameter could be decreased by increasing the grade, but this in turn would involve lowering the south end of the line in the Antelope Valley. This would materially increase the length of the longest tunnel, which will be under the crest of the Coast Range. Even if the grade were increased to 4.2 feet per mile, which is about the greatest possible, the pipe still would have to be fully six feet in diameter and would cost about as much as the concrete conduit. The possible power development would be reduced over 75 per cent., because there would be but one-fourth the amount of water and the increased grade of the pipe line would leave less fall for water power. The construction of tunnels would not be avoided by substituting a pipe line for an Aqueduct, and these tunnels are the most expensive construction. They fix the length of time required to complete the work

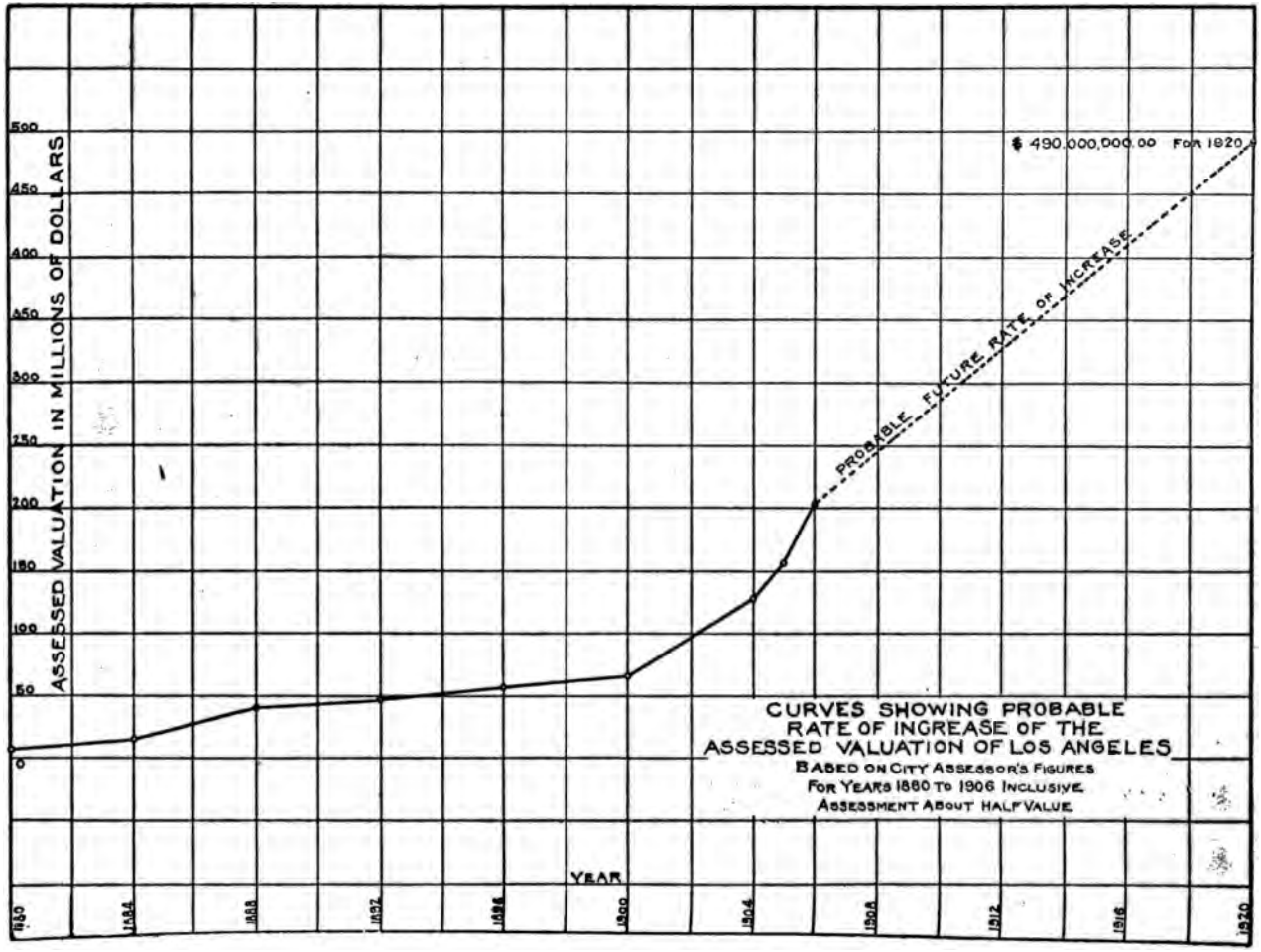
BOND ISSUE.

It is a ground for congratulation that the City Council has concluded to submit to the people the question of authorizing at once the entire bond issue of $23,000,000. It will be desirable to enter into a number of long time contracts for the driving of the long tunnels. The contractor who is given long-time contracts for the excavation of the canal or its lining, can afford to buy much more complete equipment. In order to enter into these long-time contracts it will be necessary that the funds will be available throughout a term of years, for the payment of the city's liabilities.

In starting a great work of this kind, a very large percentage of the expenditures must be put into equipment and organization; so that with, say, 50 per cent. of the funds expended, it very seldom follows that 50 per cent. of the work will be performed. After the organization and equipment has been assembled, the latter part of the work should go with relatively greater rapidity and smaller expense. It is frequently difficult to make this plain to those unfamiliar with works of this kind, but anyone connected with large construction enterprises will fully appreciate this condition.

A diagram is presented herewith (Figure 1) showing the rate of growth of the City of Los Angeles from 1880 to date. The increase is remarkable and probably as rapid as that of any city in the Union. In 1880 the population was 11,093; in 1890 it was 50,395; in 1900 it was 102,479, and in 1906, as indicated by the school census, the population was about 240,000. Projecting into the future the rate of growth during the last six years, indicates an increase at the rate of 25,700 per year. The rate of growth during the last three years, however, is 36,700 per year. This rapid increase in population has a direct bearing on the necessity of providing for an additional water supply.

The following diagram shows the growth in assessed valuation of city property. According to the State law, the bonded debt of the City for all classes of bonded debts, including water works and sewers, is limited to 15 per cent. of its assessed valuation. For the year 1880-81 the assessed valuation of city property was $7,259,568. In 1890-91 it was $49,320,670. In 1900-01 it was $65,599,920. In 1904-05 the assessed valuation was $126,126,563. In the year 1906 it was $202,985,704. As regulated by this 15 per cent., the bonding power of the City increased between 1902-03 and 1904-05, from $12,962,510 to $18,918,984, or about $6,000,000. During the last two years the advance has been from $18,918,984 to $30,447,855, an increase in bonding power in two years of $11,528,871. This increase in bonding power during the past year


ASSESSED VALUATION IN MILLIONS OF DOLLARS
500
450
400
350
300
250
200
150
100
50
0
$ 490,000,000.00 FOR 1920
PROBABLE FUTURE RATE OF INCREASE
CURVES SHOWING PROBABLE
RATE OF INCREASE OF THE
ASSESSED VALUATION OF LOS ANGELES
BASED ON CITY ASSESSOR'S FIGURES
FOR YEARS 1880 TO 1906 INCLUSIVE.
ASSESSMENT ABOUT HALF VALUE.
YEAR
1880
1884
1888
1892
1896
1900
1904
1908
1912
1916
1920

has been $7,000,000. There are outstanding about $6,800,000 in City bonds of all classes. It is proposed to issue $23,000,000 in bonds for the Los Angeles Aqueduct. This would make a total bonded debt of $29,800,000, which is $647,000 less than our ultimate bonding power. The next City assessment will be made during the coming summer, and if the same rate of increase occurs for this fiscal year that occurred during the previous year, there will be added $7,000,000 more to our bonding power.

In discussing this bond question, it is well to remember that street improvements are usually assessed against adjoining property, and are not paid for by municipal bonds. School-houses may also be provided for under a State bonding law, the assessment in this case being made against the Los Angeles school districts.

The California Legislature in February, 1907, passed an Act amending an Act entitled: "An Act authorizing the incurring of indebtedness by cities, towns and municipal corporations for municipal improvements, and regulating the acquisition, construction or completion thereof." This Act is given as Appendix L. Its purpose is to amend the State bonding law to meet the requirements of the City in the bond issue for the Los Angeles Aqueduct.

In closing this report, particular attention is called to the fact that in building our own cement plant and in constructing a concrete aqueduct, the bulk of the expenditures will be for labor and material, which will be supplied locally. The money that is used for this construction will stay in and around Los Angeles, and will not be sent to Eastern manufacturers, as would be the case, for instance, if steel pipe were used.

Particular mention should be made of the manner in which the various official and commercial organizations of Los Angeles have consulted and co-operated with each other, in all the vital stages of this enterprise. There has practically been no dissension, no marked difference of opinion, either as to the general advisability of the enterprise, or as to the policy for carrying it out.

Respectfully submitted,

(Signed) WM. MULHOLLAND,

Chief Engineer.

APPENDICES

APPENDIX A.

REPORT ON UNDERGROUND WATERS IN THE VICINITY OF LOS ANGELES.

By W. C. Mendenhall, Geologist, U. S. Geological Survey.

Two years ago some interest was excited in Southern California by publications and public utterances to the effect that the amount of water which can be safely withdrawn from our underground basins is not unlimited, and that in some localities at least, the limit of safe and conservative development had then been reached. These conclusions were based upon a careful study of conditions in the field, involving the examination of about 11,000 wells of all types, an accurate mapping of artesian areas past and present, and a study of such direct data as then existed upon the fluctuations of ground water levels, under the influence of varying annual rainfall on the one hand and withdrawals of water by artesian or pumped wells on the other.

COMPLEXITY OF THE PROBLEM.

It developed in the course of the study that conditions were very complex, in that our ground waters existed in a number of more or less completely separated basins; that each of these basins had its own water supply, perhaps differing materially in effectiveness from that of its neighbor; that the amount of development in one basin differed greatly from that in another, and hence that while widespread tendencies towards excessive drafts upon the underground supplies might be observed, in reality each locality, or at aleast each separate underground basin, presented a separate problem, to be correctly solved only by a study of local conditions.

Further uncertainties arose from the fact that up to the year 1900, the country had passed through a long period of low rainfall, which included the year of lowest precipitation of record in this vicinity, and that from 1900 to 1904 we had had only about the average rainfall, with alternate years of slight excess and slight deficiency, so that for a decade previous to the enunciation of the conclusions in question, there had been no opportunity to study the effect upon our subterranean resorvoirs of really heavy precipitation.

So little attention had been paid to underground waters before this decade, that information as to conditions during the preceding epoch of heavy rains was extremely fragmentary and unreliable. As soon as the condition of dependence of underground basins upon local rainfall became thoroughly understood, all thoughtful students of the situation recognized at once that this low

rainfall would itself cause a general lowering of water levels, and, indeed, to it as a cause had been imputed such declines as had been recognized. Furthermore, evidence of the most definite sort, that is, measurements upon the rise and fall of the ground water levels, systematically maintained through long enough a period of years to give a reliable foundation from which to reason, were practically non-existent. Upon only two wells in Southern California, one near Anaheim, owned by Mr. J. B. Neff, and the other in the San Bernardino Basin and belonging to the Riverside Trust Company, had continuous measurements been made through a long series of years.

These uncertainties and indefinite elements in the problem were recognized only too fully by those who were endeavoring to see clearly through them to a well-founded conclusion as to the safe and proper use of our ground waters, a conclusion which would be a dependable guide for those who, like the Los Angeles Water Board, are forced to determine far-reaching policies, upon which should depend the welfare of our growing communities now and in the future.

It may be accepted then, that it was not lightly nor without a full sense of responsibility, that the conclusion was announced that in many of our communities an increase in the development of underground waters must be checked, if it was not the desire to develop the present at the expense of the future, and that policies such as reforestration improvements in irrigation practice and the spreading of flood waters over the alluvial fans, must be adopted in order to lessen the waste of the abundant winter waters, increase the amount of the important summer flow and recharge underground basins.

It is not surprising, in view of the complex elements in the situation, that these conclusions were not unreservedly accepted, nor that opposing ideas have been vigorously presented, either through the press, by letters, or in proposals to make large withdrawals of yround waters for irrigation or as sources of municipal supply. Indeed, it is never well that a conclusion of any import to an individual or a community be unreservededly accepted when first enunciated. Discussion and criticism are healthy, they add new points of view and new data, they eventually eliminate whatever of error there may have been in the original pronouncement, and they lead to a wide recognition of whatever of value it may have contained.

NEW EVIDENCE.

As soon as the significance to Southern California of the problem of its ground waters became evident, and the dearth of evidence as to variations in their level appeared, the United States Geological Survey selected about 100 wells, distributed throughout the valley from Santa Monica to San Jacinto, and began systematic measurements upon them. These measurements have now been under way about two years, and are beginning to yield evidence from which conclusions can be drawn. Furthermore, both these years have been years of rainfall well above the average, and since two seasons in succession of rainfall above the average had not occurred before in 16 years, it is seen that especially significant evidence of a kind which was not in existence before the measurements were undertaken is now becoming available. It is the desire to present a summary of the conclusions to be reached from an examination of that part of this evidence that concerns Los Angeles, that prompts the preparation of this article.

FUNDAMENTAL ELEMENTS OF THE PROBLEM.

As a preliminary it is perhaps well to state again some of the fundamental facts which control the ground water situation, although these are now becoming familiar through constant reiteration. Our ground waters are stored in subterranean reservoirs which are just as definite receptacles as the reservoirs built by man, but are vastly greater in extent. Like the man-made basins, they differ from one another in outline and depth and capacity. Unlike those which are made by engineering skill, we are usually unable to measure directly their dimensions and their capacity. They differ again, from the majority of artificial basins, in that they are filled to the level of the lowest point in their rim by loose sand and gravel and clay, which has been swept into them by the streams which flow to them or across them from the adjacent mountain masses.

EXAMPLES.

The San Fernando Valley is a typical reservoir of this character. Its depth is not known, but we do know that the relatively impervious bedrock which runs and underlies it, holds the waters that run into it from the surrounding ranges until they rise to the level of the lowest point in the rim, and flow out there as the Los Angeles River. The San Gabriel Valley is another such basin, which drains through the Paso de Bartolo; the San Bernardino Valley is still another, and the Coastal Plain, between the Puente Hills and the Cerritos or Dominguez Ridge, is the largest of all. Since the basins are all filled by gravels and sands and clays, the water can only occupy the interstices between the individual soil particles. It may be stated in a very general way that these pores occupy from 20% to 30% of the whole alluvial mass. As streams discharge into the basin at one border and sink, the water fills the pores, moves slowly through them to a point of outlet and there flows away. This slow general movement, from the higher parts of a basin to the lowest, from the many points of inflow to the one point of outflow, has come to be called in the California courts "percolation."

Since these great gravel and sand-filled valleys are merely underground basins, the water in them is subject to the same general laws that govern other reservoirs. If water enters them faster than it is withdrawn, they will overflow; if it is withdrawn from them faster than it enters, the water level in them will fall. The source of supply is the rainfall, and the sources of drainage are the natural springs, and the wells pumped and flowing, which supply cities, manufacturing plants and irrigation systems.

RAINFALLS.

Los Angeles rainfall records have now been maintained for 29 seasons, and the average for this period is 15.60 inches. Students of meteorology tell us that records of 35 years duration give averages which are witihn 2% of the correct final average. The Los Angeles average is not finally determined, therefore, but it is probably within 5% of the correct final figure. Accepting this average, then, we find that the rainfall of 18.65 inches during the winter of 1905-6 was nearly 20% above the average, and that of 19:52 inches for the preceding winter was 25% above the average.

This excess has given a large supply of gravity water to irrigation systems,

and so has greatly reduced the draughts on those auxiliary pumping plants which are used only when gravity waters are insufficient. It has, of course, resulted in a heavy runoff, and has therefore made available an unusually abundant supply of water for absorption by the sands and return to underground reservoirs. Clearly under these conditions, our ground waters, if no more is withdrawn from the reservoirs than is returned during average years, should show a marked improvement in condition. A rise in the ground water levels at this time, therefore, may not mean that ground waters are not used in excess, because with a rainfall so much above the average, ground water levels which decline during average years may recover somewhat, but clearly, if water levels have fallen during these years, excessive use is indicated.

RECORD WELLS.

In 28 wells lying east, west and south of Los Angeles and south of Whittier, wells whose records are not confused by imperfect measurements, the influence of nearby pumping plants or changes in depth or character since measurements began, one-half show a net rise in the water plane in the last two years, and one-half a net decline. These wells are fairly distributed over the lowlands about Los Angeles, and they probably indicate quite closely general conditions in the nearby underground reservoirs.

When we investigate the location of those areas which show losses and of those which show gains, two facts which we should expect appear. The losses are in those areas where most pumping plants have been installed, and the gains in those areas of less intense development; and again, the losses are remote from the channels of the large streams and the gains are near them. Thus south from Los Angeles toward Howard Summit, all of the record wells show losses. There are many pumping plants in this area, and it is several miles from the channel of Los Angeles River.

West of Los Angeles toward Cienega Station, and further north in the vicinity of Colegrove, the measurements indicate net losses. Still farther west, in the lowlands extending south from Sherman, there have been recoveries, while in the vicinity of Palms, both gains and losses are recorded in different wells.

South of Whittier toward Norwalk, and in the vicinity of the San Gabriel Channel south of the Paso de Bartolo, there have been distinct gains, and this is equally true in the El Monte basin north of the Paso de Bartolo.

Developments in the El Monte basin are not as yet extensive, and the flood waters of the San Gabriel River absorbed by the sands and gravels of its bed during the last two winters have materially raised the water plane near the river channel.

Wells in Pasadena, near the south end of Orange Grove Avenue and on Colorado Street, between Pasadena and Lamanda Park, show net losses. These latter wells are probably affected by the intense development in North Pasadena and at the Devil's Gate.

The water in the Neff well at Anaheim was 1 ft. 4 in. higher on November 30, 1906, than on December 1st, 1904. On December 1st, 1905, it was 8 in. lower than one year before and 2 ft. lower than one year later. The gain during 1905-6, as compared with the loss during 1904-5, shows the cumulative effect of the two years' heavy rainfall. Should these two years be followed by other

years in which the precipitation is heavy and well distributed, more general recoveries should follow, and the declines be checked for a time in all areas except perhaps a few in which wells are most numerous and pumping is most continuous.

The new evidence which the last two years have supplied us, then, seems to support substantially the conclusions reached before this evidence became available. With two successive winters of heavy rainfall, ground water levels have recovered in favorable situations, and where pumping has not been extensive, but over about half the area adjacent to Los Angeles, less favorably situated or more heavily pumped, declines have continued. With average rainfall it is safe to say there would be but a limited area that would hold its own. With substantially less than average rainfall, declines will be well nigh universal. As the situation stands now, ground water levels generally fall with average and less than average precipitation. They partially recover only when the rainfall is well above the average.

NEED OF OWENS VALLEY WATERS.

The bearing of this situation upon the wisdom of Los Angeles' movement to secure Owens Valley waters may well be briefly discussed. Contiguous to Los Angeles on the south is the Coastal Plain, which contains the largest body of water-bearing land in Southern California, and but a short distance away to the east lies the San Gabriel basin. In the southern part of this basin, near El Monte, lies an area underlain by a valuable body of ground waters, which have not as yet been seriously taxed by development. These two regions are probably the best in the southern part of the State, in point of view of underground water supply, and both have been considered at various times when the question of a supply for the City of Los Angeles to be secured from nearby points has been under discussion. The data which have already been presented prove that in that portion of the Coastal Plain which lies immediately south of Los Angeles, water levels have been declining during the past two years, in spite of the fact that these years have covered a period of very much more than normal rainfall. In an area farther to the southeast, near the San Gabriel channel, water levels have recovered during this period, while still farther eastward, in the vicinity of Anaheim, water levels fell during the first year of heavy precipitation and rose during the second; while in the period from 1900 to 1904, a time of approximately average rainfall for this section of the State, moderate declines are recorded.

Within the Coastal Plain there are at present 100,000 acres of land under irrigation, while approximately four times that area is capable of irrigation if water were available for this purpose. But the ground water supply is clearly overtaxed with the developments at present carried out in at least a portion of this area, while in the greater part of it it is probable that developments have been carried quite as far as they can be without danger of a constantly declining ground water level and a consequent constantly increasing cost of waters in use for irrigation. It is clearly not possible to develop permanently enough of these waters to irrigate the remaining lands capable of irrigation within the Coastal Plain.

Under these circumstances, if the City of Los Angeles were to enter this field and establish pumping plants for the purpose of securing a supply of water adequate for domestic purposes, it must enter into competition with the agri-

cultural interests already established there, and practically eliminate the possibility of further extending the agricultural areas. It is obviously unwise, even if the California laws as at present interpreted would permit of such a policy, for the city to develop, at the expense of its surrounding tributary agricultural districts, and its entry into the Coastal Plain will inevitably be at the expense of these districts.

The situation in the San Gabriel Valley in the vicinity of El Monte differs somewhat from that in the Coastal Plain. Developments of the underground waters there are not as yet extensive, and the supply appears not to be overdrawn. It is indeed probable that it is capable of further development without serious depletion; but, as in the case of the Coastal Plain, there are large areas of agricultural lands in the San Gabriel Valley itself, and in the edge of the Coastal Plain below the Paso de Bartolo, which can be reclaimed by the use of these waters, if it shall seem desirable to develop them further, and this use will be rendered impossible if the city enters the district and pumps out large and constantly increasing quantities to supply its own needs.

Furthermore, there now head in and above the Paso de Bartolo a number of important canals, which are supplied by the waters that rise in and near the Pass, and which, in turn, supply irrigating waters to accessible lands in the region to the south and west. The effect of the development of underground waters in a region where under natural conditions the surplus rises to the surface in a series of springs, is to reduce the flow of these springs, and as development proceeds, eventually to cause their disappearance; springs of this type are extremely sensitive to the installation of pumping plants in their vicinity and since so many canals on and above the Paso de Bartolo are supplied exclusively by them, there is little doubt but that extensive developments there would affect the supply now taken by these canals, and so would lead to extended litigation, in which either the agricultural lands which utilize the canal waters would be deprived of their supply, or the city would lose its right to pump.

During the dry period through which Southern California has lately passed, one of the canal systems heading here in the Pass was forced to install a pumping plant in order to keep its supply up to the normal. This fact indicates that but little, if any, more water now rises in the Paso de Bartolo than is required by the interests which utilize it, and indicates a strong probability that any developments which will tend to interfere with this supply will at once make themselves felt through a reduction of the flow of natural springs.

Since these two areas, the Paso de Bartolo and the Coastal Plain, are not only the best water-bearing districts near Los Angeles, but are the best in Southern California, obviously, if it is unwise to further tax them by additional developments, it would be still more unwise to invade other of the water-bearing lands more remote from the city. So far as the ground water situation is concerned, therefore, the policy of the city in going to a distant source for its water supply is not merely wise, it is absolutely necessary, if the city's future growth is not to be at the expense of neighboring communities.

APPENDIX B.

MINUTES OF THE BOARD OF WATER COMMISSIONERS RELATIVE TO THE NEGOTIATIONS WITH FRED EATON.

May 22, 1905.

"**Whereas,** It has become manifest to the Board that the present water supply of the city is now scarcely adequate to the needs of its inhabitants, and, if the present rate of increase of the population shall continue, will soon be insufficient to meet the demand of the city for water for necessary municipal and domestic purposes; and,

"**Whereas,** The members of this Board feel that immediate steps should be taken to secure such additional water rights as will insure an adequate supply of water for the future needs of the city, and the Board has, with this end in view, caused to be made through investigations as to the various sources of supply which are available and would afford the volume of water required by the city; and,

"**Whereas,** Frederick Eaton has made and presented to the Board a written proposal to sell to the city certain lands, land claims and water rights located in what is known as Owens Valley, in Inyo County, in this State, along and in the vicinity of Owens River, said lands comprising about 12,000 acres of patented land, and about 8000 acres for which State scrip certificates have been issued, entitling the holder to patents, with appurtenant water rights, which investigations by the Board show amount to a constant flow of several thousand inches, and together with the lands and water rights covered by the options hereinafter mentioned, will afford an adequate supply of water for all the future needs of the city, at and for the price of $450,000, payable in installments, as set forth in said written proposal; and,

"**Whereas,** J. B. Lippincott, civil and dydrographic engineer, has been employed by the Board to co-operate with Mr. Mulholland, superintendent of the water works, in making an investigation of all available sources of water supply for this city, and they have filed with the Board their report upon that subject; and it appears therefrom that, volume of water, cost of acquisition and delivery, and engineering difficulties considered, the water shed of Owens River, among all possible sources of supply, affords the best for the purposes of the city, and that the lands and water rights embraced in the proposal of Mr. Eaton, besides affording a large supply of water, have such advantages of location, with reference to the Owens River Valley, as to render its immediate acquisition of primary importance to the city; and,

"**Whereas,** The City Attorney has advised the Board that it has power under the charter to purchase any properties, including water and water rights, outside the limits of the city, that may be necessary for the maintenance or

extension of the municipal water works and the means for supplying the city and its inhabitants with water;

"**Now, Therefore, Be It Resolved:** That the offer of Mr. Eaton be accepted, and that the President of the Board be authorized to enter into a contract on behalf of the Board for the purchase of the properties and option described in such proposal, and that such contract provide that, in consideration of such purchase, said Frederick Eaton assign and transfer to the Board all options and contracts held by him or under his control for the purchase of any lands, waters, water rights or interests in water or ditch companies in the Owens River Valley south of the north line of township 10, south of Mount Diablo Base."

(Ayes and Noes, Carried.)

June 6, 1905.

"Mr. Goudge then presented and read the draft of a second proposed contract between Frederick Eaton and the Board of Water Commissioners for the sale and assignment to the Board of certain options to buy lands, water rights, etc., in the Owens River Valley, as follows:

This Memorandum of Agreement, made this 6th day of June, 1905, by and between Frederick Eaton, of the City of Los Angeles, State of California, first party, and the Board of Water Commissioners of the City of Los Angeles, State of California, second party:

Witnesseth:

That said first party, for and in consideration of the sum of $1.00 to him in hand paid by said second party, the receipt of which is hereby acknowledged (and also in consideration of the execution by said second party contemporaneously herewith of a contract between the parties hereto, whereby said first party undertakes and agrees to sell, transfer and convey to said second party certain land and water rights and other properties and rights situated in the Counties of Inyo and Mono, State of California, for the sum of $450,000, payable as follows: $50,000 upon the execution of said last mentioned contract by the parties hereto; $50,000 on or before October 1st, 1905; $50,000 on or before November 1st, 1905; $50,000 on or before December 1st, 1905; and the remaining $250,000 on or before December 1st, 1907, with interest on all deferred payments at the rate of five per cent per annum, payable semi-annually as in said agreement prescribed), hereby sells, assigns and transfers to said second party all the options hereinafter described for the purchase of certain lands, water rights and interests in water ditches; the names of the persons from whom said options have been obtained, the descriptions of the properties purchasable thereunder and the prices of said properties, being respectively as follows, to-wit:

John R. Turner. Option expires July 5th, 1905. S. ½ N. W. ¼ S. W. ¼ N. E. ¼ W. ½ Section 35; W. ½ and W. ½ of E. ½ Section 36, Township 13 S., Range 35 E., M. D. M. W. ½ S. W. ¼ Section 23; N. ½ N. W. ¼ S. E. ¼ N. W. ¼ E. ½ S. W. ¼ and S. W. ¼ S. E. ¼ Section 26; N. ½ N. E. ¼ S. E. ¼ N. E. ¼ E. ½ of S. E. ¼ of Section 35; S. W. ¼ S. W. ½ Section 36,

Township 15 S., Range 36 E., M. D. M. N. E. ¼ N. E. ¼ Section 2; N. ½ N. W. ¼ S. E. ¼ N. W. ¼ S. W. ¼ N. E. ¼ N. ½ S. E. ¼ and N. E. ¼ S. W. ¼ Section 1, Township 16 S., Range 36 E., M. D. M. Also the S. ½ N. W. ¼ and E. ½ of S. W. ¼ Section 6, Township 16 S., Range 37 E., M. D. M. Containing 1800 acres of land, more or less, extending along the river for a distance of over six miles; and 100 shares of the capital stock of the New Stevens Ditch Co. 50% at exercise of option, balance on or before one year, bearing interest at 9% gross. Price.....$13,500.00

Mark Hand. Option expires July 4, 1905. W. ½ S. E. ¼ Section 32; S. E. ¼ Section 32, Township 14 S., Range 36 E., M. D. M. And N. W. ¼ N. E. ¼ Section 5, Township 15 S., Range 36 E. 50% exercise of option, balance on or before one year at 8%. Contains 160 acres, and extends along the river ½ mile. Price...$ 1,600.00

Mark Hand. Option expires July 4, 1905. S. E. ¼ N. W. ¼ Section 13; N. E. ¼ of S. W. ¼ Section 13; S. ½ of N. E. ¼ Section 13, and N. ½ of S. E. ¼ Section 13, Township 14 S., Range 35 E, M. D. M. The S. W. ¼ N. W. ¼ and N. W. ¼ of S. W. ¼ Section 18, Township 14 S., Range 36 E., M. D. M. Containing 320 acres and extending along the river....., toegther with 225 shares of the capital stock of the New Stevens Ditch Co. 50% at exercise of option, balance on or before one year, at 8%. Price .....$ 2,400.00

H. C. Hamilton. Option expires July 6, 1905. The S. E. ¼ of S. W. ¼ of Section 29; E. ½ N. W. ¼ and S. W. ¼ of N. E. ¼ Section 32, Township 14 S., Range 36 E., M. D. M. Containing 160 acres, extending along the river one mile, together with 100 shares of the capital stock of the New Stevens Ditch Co. 50% at exercise of option, balance on or before one year at 8%. Price.....$ 1,850.00

Sarah C. F. Wrinkle. Option expires July 5, 1905. S. ½ S. E. ¼ Section 13; N. E. ¼ N. ½ S. E. ¼ Section 24, Township 14 S., Range 35 E., M. D. M. S. ½ S. W. ¼ S. W. ¼ S. E. ¼ Section 18; the N. W. ¼ W. ½ N. E. ¼ S. E. ¼ N. E. ¼ N. ½ S. W. ¼ S. E. ¼ S. W. ¼ N. ½ S. E. ¼ S. E. ¼ Section 19; the E. ½ N. W. ¼ N. E. ¼ Section 30, Township 14 S., Range 36 E., M. D. M. The W. ½ S. E. ¼ Section 17; N. W. ¼ Section 2; N. ½ S. W. ¼ Section 2; W. ½ S. E. ¼ S. E. ¼ S. E. ¼ Section 3; N. E. ¼ N. W. ¼ N. ½ N. E. ¼ Section 10; N. W. ¼ of N. W. ¼ Section 11 in Township 15 S., Range 35 E., M. D. M. Containing 1800 acres and extending along the river about one mile; together with 1094 shares of the capital stock of the New Stevens Ditch Co., and all the water in Hog Back Creek. Price.....$21,500.00

Jno. J. Stewart. Expires July 3, 1905. S. E. ¼ of S. E. ¼ Section 18; N. E. ¼ of N. E. ¼ Section 19, Township 14, Range 36 E., M. D. M. Containing 80 acres, and extending along the river one-half miles, together with 40 shares of the New Stevens Ditch Co. stock. Cash on exercise of option. Price.....$ 500.00

E. H. Edwards. Option expires July 6, 1905. An undivided ¼ interest in the following described property: W. ½ of E. ½ and E. ½ Section 1; E. ½ of N. E. ¼, N. E. ¼ of S. E. ½ of Section 2; N. ½ S. E. ¼ N. E. ¼ S. W. ¼ Section 12; N. ½ of N. E. ¼ Section 13, Township 14 S., Range 35 E., M. D. M. S. ½ S. W. ¼ of Section 7; N ½ of N. W. ¼ Section 18, Township 14, Range 36 E., M. D. M. Together with 551 shares of the capital stock of the New Stevens Ditch Co., and all its interest in said ditch. 50% at exercise of option, balance on or before one year at 8%. Price ..... $ 4,777.50

Maggie Skinner. Expires July 5, 1905. S. E. ¼ N. W. ¼ N. E. ¼ of S. W. ¼; the N. ½ of S. E. ¼ of Section 18, Township 14 S., Range 36 E., M. D. M., containing 160 acres, extending along the river ¼ mile; together with 25 shares of the capital stock of the New Stevens Ditch Co. 50% at exercise of option, balance on or before one year at 8%. Price..... $ 1,262.50

A. W. Eibeshutz. Expires July 7, 1905. S. E. ¼ of N. W. ¼ S. W. ¼ of N. E. ¼ N. E. ¼ of S. W. ¼ and N. ¼ of S. E. ¼ Section 7, Township 14 S., Range 36 E., M. D. M., containing 160 acres, and extending along the river ½ mile. 50% at exercise of option, balance on or before one year at 8%. Price..... $ 960.00

I. H. Mulholland. Option expires July 1, 1905. N. ¼ of N. E. ¼ Section 14; W. ½ of S. E. ¼ S. W. ¼ of the N. E. ¼ and the W. ½ of Section 11, Township 13 S., Range 35 E., M. D. M., containing 480 acres extending along the river about 1¼ miles; together with all the ditch rights in the Mulholland Ditch, which has a water right of 500 inches. 50% at exercise of option, balance on or before one year at 9%. Price..... $ 7,200.00

And said first party, in consideration of the premises, also hereby agrees to sell, assign and transfer to said second party, any and all options to purchase lands situate in the County of Inyo south of the north line of Township 10 south, Mount Diablo Base, or waters, water rights or interests in water ditches or water canals located south of said line that may be hereafter purchased or acquired by said first party at and for the price of the actual cost and expense incurred and paid by said first party in purchasing or acquiring said options.

Provided, however, and it is expressly stipulated and agreed, by and between the parties hereto, that in the event said second party shall fail or neglect to pay when due any installment of the purchase price required to be paid by it under the aforesaid contracts executed by the parties hereto contemporaneously herewith for the purchase at and for the sum of $450,000 of the property described in said contract, or shall fail or neglect to pay when due any installment of the interest upon the deferred payments of such purchase price, then and in that event said second party shall, upon demand of said first party, re-convey and re-assign, or cause to be re-conveyed and reassigned, unto said first party, all rights, titles and interests in or to any lands, waters, water rights, water ditches or water canals, or interests therein, theretofore acquired by it under any of the options that are hereby or may be hereafter assigned or transferred to said second party under or pursuant to

this agreement, at and for a price equal to the actual cost to said second party of said options, rights, titles or interests; provided, however, that said demand and payment of said price shall be made by said first party within not exceeding six months after the neglect, failure or default on the part of said second party which will entitle said first party to such reconveyance and re-assignment, as aforesaid.

It is hereby stipulated that all the covenants and agreements herein contained shall inure to the benefit of and bind the parties hereto, their heirs, executors, administrators, successors and assigns.

In Witness Whereof, said first party has hereunto set his hand, and said second party has, by its President being thereunto authorized by a resolution of said second party, caused its name to be hereunto subscribed, the day and year first above written.

(Signed) FREDERICK EATON.

BOARD OF WATER COMMISSIONERS OF THE CITY OF LOS ANGELES.
By JOHN J. FAY, JR., President.

Attest: JAS. P. VROMAN,
Secretary.

"Mr. Mead moved the adoption of the contract as read, and that the President and Secretary of this Commission be authorized for and on behalf of the Commission to sign, execute and deliver same.

"Seconded by Mr. Sherman, and carried by the following vote:"

(Ayes and Noes, Carried.)

June 6th, 1905.

"Mr. Goudge of the City Attorney's office presented and read draft of a proposed contract between Frederick Eaton and the Board of Water Commissioners for the purchase by the Board of certain lands and other properties in the Owens River Valley as follows:

This Memorandum of Agreement, made and entered into this 6th day of June, 1905, by and between Frederick Eaton, first party, and the Board of Water Commissioners of the City of Los Angeles, State of California, second party,

Witnesseth:

That said first party, for and in consideration of the payments of money hereby agreed to be made by said second party, does hereby agree to grant, sell, convey, transfer and assign, or to cause to be granted, sold, conveyed, transferred and assigned, to said second party, its successors or assigns, all of the following property, to-wit:

First: All of those parcels of land, situate in the County of Inyo, State of California, hereinafter referred to as Patented Lands, and comprising the following described lands, to-wit:

S. ½ of N. E. ¼; N. E. ¼ of S. E. ¼, Sec. 22. N. W. ¼ of S. W. ¼, Sec. 23, Tp. 10 S., R. 34 E.

S E. ¼ of S. E. ¼ of Sec. 26; E. ¼ of N. E. ¼, and N. W. ¼ of N. E. ¼ of Sec. 35, Tp. 10 S., R. 34 E.

W. ½ of S. E. ¼; S. W. ¼ of N. E. ¼; S. E. ¼ of N. W. ½, Sec. 26, Tp. 10 S., R. 34 E.

S. ½ of N. W. ¼; S. W. ¼ of N. E. ¼, Sec. 11, Tp. 10 S., R. 34 E.

S. W. ¼ of S. W. ¼, Sec. 15.

N. ½ of N. W. ¼, Sec. 22.

E. ½ of N. E. ¼ of N. E. ¼, and S. W. ¼ of N. E. ¼ of N. E. ¼ of Sec. 21.

E. ½ of N. E. ¼; E. ½ of S. E. ¼, Sec. 11, Tp. 11 S., R. 34 E.

N. E. ¼ of Sec. 15, Tp. 11 S., R. 34 E.

E. ½ of N. E. ¼; N. W. ¼ of N. E. ¼; N. E. ¼ of S. E. ¼, Sec. 33, Tp. 12 S., R. 35 E.

S. W. ¼ of N. W. ¼; N. ½ of S. W. ¼; S. E. ¼ of S. W. ¼, Sec. 28, Tp. 12 S., R. 35 E.

S. E. ¼ of S. W. ¼ of Sec. 14; N. W. ¼ of N. E. ¼, and N. E. ¼ of N. W. ¼ of Sec. 23, Tp. 11 S., R. 34 E.

N. W. ¼ of S. W. ¼, Sec. 14, Tp. 11 S., R. 34 E.

W. ½ of E. ½ and E. ½ of W. ½, Sec. 11.

W. ½ of E. ½; N. E. ¼ of N. E. ¼; E. ½ of N. W. ¼; N. E. ¼ of S. W. ¼, Sec. 14.

N. E. ¼ of Sec. 16, Tp. 11 S., R. 34 E.

W. ½ of S. W. ¼; S. E. ¼ of S. W. ¼, Sec. 14.

S. E. ¼ of S. E. ¼ of S. W. ¼ of Sec. 15.

N. ½ of N. E. ¼ of Sec. 22 .

N. W. ¼ of Sec. 23, Tp. 10 S., R. 34 E.

W. ½ of N. W. ¼; N. ½ of S. W. ¼, Sec. 13, Tp. 11 S., R. 34 E.

N. E. ¼ of Sec. 10, Tp. 13 S., R. 35 E.

W. ½ of S. E. ¼; N. E. ¼ of S. W. ¼, Sec. 27, Tp. 11 S., R. 34 E.

E. ½ of N. W. ¼; N. W. ¼ of N. E. ¼; N. E. ¼ of S. W. ¼, Sec. 34; S. E. ¼ of S. W. ¼ of S. W. ¼, Sec. 27, Tp. 11 S., R. 34 E.

Lots 5 and 6 in the fractional N. E. ¼ of Sec. 6 in Tp. 13 S. of R. 35 E.

S. E. ¼ of Sec. 22, Tp. 12 S., R. 34 E.

S. W. ¼ of Sec. 11, Tp. 10 S., R. 34 E.

E. ½ of N. E. ¼; E. ½ of S. E. ¼, Sec. 27, Tp. 12 S., R. 34 E.

E. ½ of S. E. ¼; S. E. ¼ of N. E. ¼, Sec. 27; S. ½ and S. ½ of N. ½ of Sec. 26; all of Sec. 35; S. E. ¼ Sec. 34; S. ½ of N. E. ¼, and N. E. ¼ of N. E. ¼ of Sec. 34, Tp. 11 S., R. 34 E.

N. ½ of N. ½ of Sec. 2, Tp. 12 S., R. 34 E.

N. E. ¼; S. ½ of N. W. ¼; S. E. ¼ and S. W. ¼ of Sec. 34; S. ½ of S. E. ¼, Sec. 33, Tp. 9 S., R. 34 E.

S. ½ of S. E. ¼, Sec. 22; S. W. ¼ of S. W. ¼, Sec. 23; N. E. ¼ of N. E. ¼ of Sec. 27, Tp. 11 S., R. 34 E.

S. E. ¼ of N. W. ¼; N. ½ of S. W. ¼; S. E. ¼ of S. W. ¼; N. W. ¼ of S. E. ¼; S. ½ of S. E. ¼ of Sec. 23; N. E. ¼ of N. W. ¼; N. ½ of N. E. ¼ of Sec. 26, Tp. 11 S., R. 34 E.

S. W. ¼ of N. E. ¼; W. ½ of S. E. ¼; S. E. ¼ of S. E. ¼, Sec. 20, Tp. 12 S., R. 35 E.

E. ½ of E. ½; N. W. ¼ of N. E. ¼ of Sec. 4; W. ½ of N. W. ¼ of Sec. 3, Tp. 10 S., R. 34 E.

E. ½ of N. W. ¼; N. E. ¼ of Sec. 3; W. ½ of N. W. ¼; S. E. ¼ of N. W. ¼; S. W. ¼ of Sec. 2; N. ½ of N. W. ¼ of Sec. 11, Tp. 10 S., R. 34 E.

S. E. ¼ of S. W. ¼; S. ½ of S. E. ¼; N. E. ¼ of S. E. ¼, Sec. 3; W. ½ of Lots 2, 3, 4 and 5 in N. W. ¼ of Sec. 2; N. W. ¼ of Sec. 10, Tp. 13. S., R. 35 E.

S. E. ¼, Sec. 7; S. ½ of S. W. ¼ of Sec. 8; E. ½ of N. E. ¼; S. ½ of Lots 1 and 2 in N. W. ¼, and N. ½ of Lots 1 and 2 in S. W. ¼ of Sec. 18; N. W. ¼ of Sec. 17; S. W. ¼ of N. W. ¼; N. ½ of S. W. ¼; S. E. ¼ of S. W. ¼ of Sec. 20; S. ½ of Lot 2 in S. W. ¼ of Sec. 30; N. ½ of Lot 2 in N. W. ¼, and S. E. ¼ of Sec. 31, Tp. 12 S., R. 35 E.

S. E. ¼ of N. W. ¼; E. ½ of S. W. ¼; S. W. ¼ of S. E. ¼ of Sec. 24, Tp. 11 S., R. 34 E.

S. ½ of N. W. ¼; N. E. ¼ of S. W. ¼; S. W. ¼ of N. E. ¼; W. ½ of S. E. ¼ of Sec. 2; N. E. ¼ of Sec. 11; W. ½ of S. W. ¼ of Sec. 13; N. W. ¼ of Sec. 14; E. ½ of N. W. ¼, and W. ½ of N. E. ¼ of Sec. 22; W. ½ of S. W. ¼ and S. E. ¼ of S. W. ¼ of Sec. 23; W. ½ of N. W. ¼; S. E. ¼ of N. W. ¼; S. W. ¼ of N. E. ¼; N. E. ¼ of S. W. ¼ and N. W. ¼ of S. E. ¼ of Sec. 24; W. ½ of N. E. ¼, and S. E. ¼ of Sec. 25; W. ½ of N. E. ¼, and W. ½ of Sec. 26; E. ½ of N. E. ¼, and E. ½ of S. E. ¼ of Sec. 27; N. E. ¼ of N. E. ¼ of Sec. 34; N. ½ of N. W. ¼ of Sec. 35, Tp. 12 S., R. 34 E., all of Mount Diablo Base and Meridian.

And all other lands, situate in said County of Inyo, standing of record in the name of, or owned by, the Rickey Land and Cattle Company, or T. B. Rickey, or Thomas B. Rickey, and contained in any of the townships numbers ten to fifteen south, inclusive, in ranges thirty-four to thirty-six, east, inclusive, of Mount Diablo Base and Meridian.

Second: All of the right, title and interest, and all rights to obtain title, now or hereafter possessed by said first party and derived by him from the Rickey Land and Cattle Company, or T. B. Rickey, or Thomas B. Rickey, in or to those parcels of land situated in said County of Inyo, hereinafter referred to as Listed Unpatented Lands, described in certain certificates of purchase issued by the State Land Office of the State of California, and all rights, now or hereafter possessed by said first party, in or under said certificates of purchase; said certificates of purchase and the lands described therein being respectively as follows:

Certificate No. 13664 for 320 acres of land, to-wit:

Southwest quarter Section 17 and Southwest quarter Section 18, Township 12 South, Range 35 East, M. D. M.

Certificate No. 13738 for 640 acres of land, to-wit:

Northeast quarter and North half of Southeast quarter of Section 12; South half of Northeast quarter, Northwest quarter and Southeast quarter of Section 13, Township 12 South, Range 34 East, M. D. M.

Certificate No. 13739 for 593.47 acres of land, to-wit:

South half of Lot 1 in Southwest quarter, South half of Lot 2 in Southwest quarter of Section 18; Lot 2 (of Northwest quarter) of Section 19; Southeast quarter of Northwest quarter and Southwest quarter of Southwest quarter of Section 20; North half of Northwest quarter of Section 29; Southeast quarter of Northeast quarter of Section 31, Township 12 South, Range 35 East; Lot 4, East half Lot 5 and Lot 6 in Northeast quarter, and East half of Lot 6 in Northwest quarter of Section 5, Township 13 South, Range 35 East, M. D. M.

Certificate No. 13740 for 609.58 acres of land, to wit:

East half of Southwest quarter of Section 13; East half of Northeast quarter, Northwest quarter of Northeast quarter, Northeast quarter of Northwest quarter and East half of Southeast quarter of Section 24; East half of Northeast quarter of Section 25, Township 12 South, Range 34 East; Lot 2 (of Southwest quarter) of Section 19; Lot 2 (of North west quarter) and North half of Lot 2 (of Southwest quarter) of Section 30, Township 12 South, Range 35 East, M. D. M.

Certificate No. 13741 for 640 acres of land, to wit:

North half of Lot 1 (of Southwest quarter) and North half of Southeast quarter of Section 19; South half of Lot 1 (of Southwest quarter) of Section 30; North half of Northeast quarter of Section 31; Southeast quarter of Northwest quarter and East half of Southwest quarter of Section 29; East half of Northwest quarter and Southwest quarter of Northwest quarter of Section 32, Township 12 South, Range 35 East; South half of Southeast quarter of Section 5 and North half of Northeast quarter of Section 8, Township 13 South, Range 35 East, M. D. M.

Certificate No. 13669 for 601.15 acres of land, to wit:

Northwest quarter Section 12; Southeast quarter Section 11; Southeast quarter of Southwest quarter of Section 2, Township 12 South, Range 34 East; North half of Lot 1, North half of Lot 2 (of Northwest quarter) and West half of Northeast quarter of Section 18, and Lot 2 (of Northwest quarter) of Section 7, Township 12 South, Range 35 East, M. D. M.

Certificate No. 14116 for 640 acres of land, to wit:

Southeast quarter of Section 29, East half of Section 32 and Southwest quarter of Section 33, Township 12 South, Range 35 East, M. D. M.

Certificate No. 13830 for 160 acres of land, to wit:

Northeast quarter of Southwest quarter and West half of Southwest quarter of Section 14, and Northeast quarter of Northwest quarter of Section 23, Township 12 South, Range 34 East, M. D. M.

Certificate No. 13831 for 631.12 acres of land, to wit:

East half of Section 14, Northeast quarter of Section 23; Northwest quarter of Southwest quarter of Section 24, Township 12 South, Range 34 East; Lot 6 and East half of Lot 5 (of Northwest quarter) of Section 2, Township 13 South, Range 35 East, M. D. M.

Certificate No. 13832 for 640 acres of land, to wit:

West half of Section 25; East half of Northeast quarter of Section 26; South half of Southwest quarter and Southwest quarter of Southeast quarter of Section 24, Township 12 South, Range 34 East; South half of Lot 1 (of Southwest quarter) of Section 19, and Northwest quarter of Northwest quarter of Section 32, and Southwest quarter of Northeast quarter of Section 7, Township 12 South, Range 35 East, M. D. M.

Certificate No. 13670 for 519.58 acres of land, to wit:

Fractional West half of Section 6; East half of Northeast quarter and Lot 1 (of Southwest quarter) of Section 7 and Northeast quarter of Southwest quarter of Section 8, Township 12 South, Range 35 East, M. D. M.

Certificate No. 13834 for 160 acres of land, to wit:

Southwest quarter of Section 32, Township 12 South, Range 35 East, M. D. M.

Certificate No. 13742 for 520 acres of land, to wit:

Northwest quarter of Southeast quarter of Section 24, East half and East half of Northwest quarter and East half of Southwest quarter of Section 25, Township 11 South, Range 34 East, M. D. M.

Certificate No. 13744 for 333.39 acres of land, to wit:

Southwest quarter of Northeast quarter, Lot 1 and South half of Lot 2 (of Northwest quarter) and Lots 1 and 2 (of Southwest quarter) of Section 31, Township 12 South, Range 35 East, M. D. M.

Certificate No. 13746 for 240 acres of land, to wit:

South half of Northeast quarter, South half of Northwest quarter of Section 1, Southeast quarter of Southwest quarter of Section 14, Township 12 South, Range 34 East; Northwest quarter of Southwest quarter of Section 8, Township 12 South, Range 35 East, M. D. M.

Certificate No. 13833 for 480 acres of land, to wit:

Southeast quarter of Section 23; East half of Northwest quarter, Southwest quarter of Northwest quarter and Southwest quarter of Section 11, Township 12 South, Range 34 East, and Northeast quarter of Northwest quarter of Section 24, Township 11 South, Range 34 East, M. D. M.

Certificate No. 13835 for 160.38 acres of land, to wit:

Lot 2 (of Northwest quarter) and Lot 2 (of Northeast quarter) of Section 1, Township 12 South, Range 34 East, M. D. M.

Certificate No. 14155 for 360 acres of land, to wit:

Northwest quarter of Northeast quarter of Section 17, West half of Northwest quarter, Southeast quarter of Northwest quarter and Southwest quarter of Southeast quarter of Section 8, Southwest quarter of Southwest quarter of Section 6; Southeast quarter of Northeast quarter and East half of Southeast quarter of Section 6,Township 12 South, Range 35 East, M. D. M.

Certificate No. 14713 for 80 acres of land, to wit:

East half of Northeast quarter of Section 15, Township 12 South, Range 34 East, M. D. M.

Certificate No. 14332 for 320 acres of land, to wit:

West half of Section 35, Township 15 South, Range 36 East, M. D. M.

Third: All of the right, title and interest, and all rights to obtain title, now or hereafter possessed by said first party and derived by him from the Rickey Land and Cattle Company, or T. B. Rickey, or Thomas B. Rickey, in or to any lands, not hereinabove described, situated in said County of Inyo and contained in any of the townships numbers ten to fifteen south, inclusive, in ranges thirty-four to thirty-six east, inclusive, of Mount Diablo Base and Meridian, and all rights now or hereafter possessed by said first party and derived by him from the Rickey Land and Cattle Company, or T. B. Rickey, or Thomas B. Rickey, in or under any certificate of purchase not hereinabove described, issued by the State Land Office of the State of California for any lands situated in any of said townships.

Fourth: All water and water rights, and all interests, claims and appropriations in or of water or water rights, and all interests in water ditches or canals, that are in anywise appurtenant to any of the lands hereinbefore in this contract mentioned; also all rights or interests now or hereafter possessed by said first party and derived by him from the Rickey Land and Cattle Company, or T. B. Rickey, or Thomas B. Rickey, in any water rights, water canals

or water ditches, and in the surface or subterranean waters of the Owens River between the north line of township ten and south line of township fifteen south of Mount Diablo Base and in the surface or subterranean waters of the following streams, to wit: Fish Springs, Black Rock Springs, Tinemaha Creek, Taboose Creek, Goodale Creek and Division Creek, and of all other streams flowing through or across any of the lands hereinbefore mentioned, except a one-third interest in the water ditch known as the Blake and Miller Ditch, and any water rights now existing north of the north line of township ten south of Mount Diablo Base, that may be hereafter acquired by said first party.

Fifth: A perpetual right and easement in and upon the lands now or hereafter possessed by said first party and derived by him from the Rickey Land and Cattle Company, or T. B. Rickey, or Thomas B. Rickey, situated in Long Valley, Mono County, California, and lying between the level of the contour line having an elevation of one hundred feet above the mean surface level of the Owens River at a point selected by the United States Government for the location of a dam, and at which notice of the appropriation of the surface waters of the Owens River has been posted on behalf of the United States Government, and the mean surface level of said river at said point for the purpose of accumulating and impounding water on said lands up to the level of said contour line by means of a dam erected upon and across the Owens River.

At and for the price of Four Hundred and Fifty Thousand Dollars ($450,000.), in lawful money of the United States, payable as follows, to wit:

Fifty Thousand Dollars ($50,000.) cash upon the execution of this agreement;

Fifty Thousand Dollars ($50,000.) on or before October 1st, 1905;

Fifty Thousand Dollars ($50,000.) on or before November 1st, 1905;

Fifty Thousand Dollars ($50,000.) on or before December 1st, 1905;

And the remaining Two Hundred and Fifty Thousand Dollars ($250,000.) on or before two (2) years after December 1st, 1905;

All such deferred payments to bear interest at the rate of five (5) per cent per annum, reckoned from the first day of June, 1905, and payable semi-annually on the first day of December and on the first day of June of each year, and all such payments of principal and interest to be payable out of the Water Revenue Fund of the Water Department of the City of Los Angeles, or such other fund or funds of said city as may hereafter be created for the purpose of meeting said payments.

Provided, however, and it is hereby agreed, that, in case said second party pays, or causes to be paid, the full amount of said purchase price, with the accrued interest, on or before January 1st, 1906, then in that event a discount of Twenty-five Thousand Dollars ($25,000.) shall be allowed and deducted from said purchase price.

It Is Further Agreed, by and between the parties hereto, that any and all of the aforesaid payments on account of said purchase price may be by said second party used and applied to the payment or discharge, in whole or in part, of any or all taxes, assessments or encumbrances now existing, or that may hereafter subsist, except taxes for the year 1906-7, upon any of the aforementioned patented lands, or upon any of the aforementioned waters or water rights, which have been derived by said first party from said Rickey Land and Cattle Company, or T. B. Rickey, or Thomas B. Rickey.

And said first party, on receiving payment of the aforesaid purchase price, at the time and in the manner hereinbefore mentioned, agrees to execute and deliver, or cause to be executed and delivered, to said second party, or to its successors or assigns, a good and sufficient deed or deeds, conveying to said second party or its assigns, the title to all of the aforesaid Patented Lands, free and clear of all encumbrances, except taxes for the year 1906-7, together with a certificate or certificates of title thereto, issued by a reputable incorporated Abstract Company doing business in this State, certifying said title to be free and clear of all encumbrances, except the taxes aforesaid; also a good and sufficient instrument, or instruments, of conveyance, transferring to said second party, or its assigns, all of the aforementioned rights, titles and interests, and rights to obtain title, in or to the aforesaid Listed Unpatented Lands, accompanied by a certificate or certificates, issued by a reputable incorporated abstract company, or reputable attorney, doing business in this State, certifying that a patent to all of said Listed Unpatented Lands is obtainable by said second party; also a good and sufficient instrument or instruments of assignment or conveyance, conveying and transferring to said second party, or its assigns, all of the rights and interests, and all rights to obtain title, now or hereafter possessed by said first party and derived by him from the Rickey Land and Cattle Company, or T. B. Rickey, or Thomas B. Rickey, in or to any lands situate in said County of Inyo, and contained in townships ten to fifteen south, inclusive of ranges thirty-four to thirty-six east, inclusive, of Mount Diablo Base and Meridian, other than the lands hereinbefore described as Patented Lands and listed Unpatented Lands; and all of the certificates of purchase issued by the State Land Office of the State of California, hereinbefore mentioned, and all of the water and water rights and interests in water canals and water ditches hereinbefore in this agreement mentioned; and also the right and easement hereinbefore mentioned in the aforesaid lands situated in Long Valley, Mono County, California; and all other rights, interests and property herein mentioned and agreed to be delivered and conveyed by said first party to said second party; all of said deeds and instruments of conveyance, or assignments, to be duly executed, acknowledged and certified so as to entitle the same to be recorded.

It Is Further Understood and Agreed, that possession of all the property hereinbefore in this agreement mentioned, shall be surrendered and delivered by said first party to said second party when the sum of Two Hundred Thousand Dollars ($200,000.), and the interest thereon, shall have been paid by it to said first party on account of the aforesaid purchase price, and in the manner and at the times hereinbefore mentioned, provided that said first party shall have the right to retain and use all hay cut upon any of the aforementioned lands prior to June 1st, 1906, and to use and occupy said lands for pasture purposes until said date.

It Is Further Agreed, by and between the parties hereto, that in the event of the failure of said second party to pay when due any installment of the purchase price, herein mentioned, or any installment of interest upon any of the deferred payments thereof, all rights of said second party under this agreement shall thereupon cease and determine, and said second party shall forfeit all rights at law or in equity hereunder.

This contract shall bind and inure to the benefit of the parties hereto, and their respective executors, administrators, heirs, successors and assigns.

In Witness Whereof, said first party has hereunto set his hand and seal, and said second party has by its President and Secretary, being thereunto duly authorized by Resolution of said second party, caused its name to be hereunto subscribed, the day and year first above written.

(Signed.) FREDERICK EATON.

BOARD OF WATER COMMISSIONERS OF THE CITY OF LOS ANGELES.
JOHN J. FAY, JR., President.

James P. Vroman, Secretary.

"Mr. Elliott moved the adoption of the contract as read, and that the President and Secretary of this Commission be authorized for and on behalf of the Commission to sign, execute and deliver the same.

Seconded by Mr. Sherman, and carried by the following vote:"

(Ayes and Noes, Carried.)

STATE OF CALIFORNIA, } ss.
County of Los Angeles. }

On this 6th day of June, 1905, before me, M. E. Hammond, a Notary Public in and for said County of Los Angeles and State of California, personally appeared John J. Fay, Jr., and Jas. P. Vroman, known to me to be the President and Secretary, respectively, of the Board of Water Commissioners of the City of Los Angeles, who executed the within instrument on behalf of the Board therein named, and acknowledged to me that said Board executed the same.

In Witness Whereof, I have hereunto set my hand and affixed my official seal the day and year in this certificate first above written.

(Seal.) M. E. HAMMOND,
Notary Public in and for the County of Los Angeles, State of California.

STATE OF CALIFORNIA, } ss.
County of Los Angeles. }

On this 6th day of June, 1905, before me, M. E. Hammond, a Notary Public in and for said County of Los Angeles, State of California, residing therein, duly commissioned and sworn, personally appeared Frederick Eaton, known to me to be the person whose name is subscribed to the within and annexed instrument, and acknowledged to me that he executed the same.

In Witness Whereof, I have hereunto set my hand and affixed my official seal the day and year in this certificate first above written.

(Seal.) M. E. HAMMOND,
Notary Public in and for the County of Los Angeles, State of California.

June 12, 1905.

"Communication from Mr. Fred Eaton, offering his services to the Board in the matter of obtaining options in the Owens River Valley, presented as follows:

'Los Angeles, Cal., June 7th, 1905.

To the Board of Water Commissioners of the City of Los Angeles:

Gentlemen: In view of the fact that I personally conducted the negotiations in securing the options referred to in my contract with you, and am quite familiar with the properties covered by those options, and property generally in the Owens River Valley, I respectfully propose to act for the Board, in the matter of the purchase by it of such properties covered by those options as it may wish to acquire, and in obtaining ootipns on other properties in that Valley south of the north line of Townships 10 S., M. D. M., on the following terms:

$10.00 per day for time actually and necessarily spent, and my necessary expenses while about that business, not including personal living expenses.

Respectfully,

(Signed.) FRED EATON.'

Mr. Mead moved that the offer be accepted, and that Mr. Eaton be employed on the terms named. Seconded by Mr. Baker, and carried by the following vote:

(Ayes and Noes, Carried.)

July 17, 1905.

"**Resolved:** That the President of the Board, Jno. J. Fay, Jr., be and he is hereby authorized and directed to pay out of the proceeds of the warrants covered by resolutions of the Board, adopted June 12th, June 19th and July 3rd, the sum of $20,000, to be used in paying the sum of $5,000 to J. E. Coffin on account of the contract between said Eaton and said J. E. Coffin for the purchase of the option and the lands and water rights belonging to the Estate of Trenmor Coffin, deceased, described in the previous Resolution, and to pay the sum of $15,000 to the William Penn Colonial Assn. in connection with the exercise by said Eaton of said option.

Said Resolution was seconded by Mr. Baker, and carried by the following vote:"

(Ayes and Noes, Carried.)

July 17, 1905.

"Mr. Frederick Eaton, heretofore appointed by the Board to secure options for the purchase of and to purchase on behalf of the Board lands and water rights in the Owens River Valley, was present at the meeting and reported that he had a proposition from J. E. Coffin:

First: To assign and transfer to said Eaton an option held by said Coffin for the purchase of all the lands and water and water rights belonging to the William Penn Colonial Association in Owens River Valley, amounting to 12,432.99 acres of land and 17,991.57 parts out of a total of 22,000 parts of

water flowing in the canals of said Association, for the price of $150,000, payable ten per cent down, forty per cent on or before January 1st, 1906, and 50 per cent on or before January 1st, 1907, with five per cent interest on deferred payments, with a discount of five per cent if said price is paid on or before January 1st, 1906;

Second: To convey or cause to be conveyed to said Eaton certain lands and water rights now owned by the Estate of Trenmor Coffin, deceased, embracing about 1000 acres of land in said Valley, and 1000 parts out of a total of 22,000 parts of water flowing in said canals.

The amount to be paid for said option and for said conveyance to be $20,000, payable as follows: $5000 down, $2500 on or before September 1st, 1905, and $12,500 on or before January 1st, 1907, with the condition that if said J. E. Coffin fails to convey or cause to be conveyed said property owned by the estate of Trenmor Coffin, deceased, with a clear title, on or before January 1st, 1907, then, in that event, no part of said sum of $12,500 shall be paid and the obligation for the purchase, sale and conveyance of same shall thereupon cease and determine.

Mr. Elliott moved the adoption of the following resolution:

Resolved: That Frederick Eaton be authorized and directed to purchase said option and to make a contract for the purchase of the land and water owned by the Coffin Estate at the price and upon the terms named in his report, and after obtaining said option to exercise the same by paying to the William Penn Colonial Association the sum of $15,000 and by entering into a contract with said Association for the purchase of the property covered by said option, pursuant to the terms thereof.

Said Resolution was seconded by Mr. Baker, and duly carried by the following vote:''

(Ayes and Noes, Carried.)

Sept. 18, 1905.

''**Resolved:** That a warrant be drawn for the sum of $50,000 payable to the order of Frederick Eaton, in payment of the installment due to him on October first next, under and in accordance with his agreement with the Board of Water Commissioners, dated June 6th, 1905, for the sale of certain lands and water rights in the County of Inyo.''

(Ayes and Noes, Carried.)

Oct. 15, 1906.

''**Whereas,** Fred Eaton, at the request of members of the Board of Water Commissioners and the Board of Public Works, has been buying various properties in the Owens River Valley, required by the city in connection with the Owens River project, upon the understanding that he should serve without salary or allowance for expenses, and should get his compensation out of commissions paid by the seller where practicable, but if such an arrangement as to commission could not be made, that the city should pay a commission not exceeding five per cent, it also being understood, that in each case, the price to be paid for land bought should be the lowest obtainable price, and that, before

any deal is closed, the proposed purchase should be submitted to said Boards for their approval and

Whereas, it now appears to this Board that it will be more just and reasonable to all parties concerned, that the city should not require Mr. Eaton in future purchases to look to the seller of the lands for his commission.

Now Therefore, Be It **Resolved**: That it is the sense of this Board that hereafter Mr. Eaton, in negotiating for the purchase of the property required by the city in connection with its Owens River project, should secure the same at the lowest obtainable price, upon a commission of five per cent, to be paid him by the city in full compensation for his services.''

(Ayes and Noes, Carried.)

Oct. 30, 1905.

''**Resolved**: That a warrant be drawn for the sum of $50,000 payable to the order of Frederick Eaton, in payment of the installment due to him on November first next, under and in accordance with his agreement with the Board of Water Commissioners, dated June 6th, 1905, for the sale of certain lands, and water rights in the County of Inyo.''

(Ayes and Noes, Carried.)

APPENDIX C.

(Public—No. 395.)

An Act authorizing and directing the Secretary of the Interior to sell to the City of Los Angeles, California, certain public lands in California; and granting rights in, over and through the Sierra Forest Reserve, the Santa Barbara Forest Reserve, and the San Gabriel Timber Land Reserve, California, to the City of Los Angeles, California.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled. That there is hereby granted to the City of Los Angeles, California, a municipal corporation of the State of California, all necessary rights of way, not to exceed two hundred and fifty feet in width, over and through the public lands of the United States in the Counties of Inyo, Kern and Los Angeles, State of California, and over and through the Sierra and Santa Barbara Forest Reserves and the San Gabriel Timber Land Reserve, in said State, for the purpose of constructing, operating and maintaining canals, ditches, pipes and pipe lines, flumes, tunnels and conduits for conveying water to the City of Los Angeles, and for the purpose of constructing operating and maintaining power and electric plants, poles and lines for the generation and distribution of electric energy, together with such lands as the Secretary of the Interior may deem to be actually necessary for power houses, diverting and storage dams and reservoirs, and necessary buildings and structures to be used in connection with the construction, operation and maintenance of said water, power and electric plants, whenever said city shall have filed, as hereinafter provided, and the same shall have been approved by the Secretary of the Interior, a map or maps showing the boundaries, locations and extent of said proposed rights of way for the purposes hereinabove set forth.

Sec. 2. That within one year after the passage of this Act the City of Los Angeles shall file with the registers of the United States Land Offices in the districts where the lands traversed by said rights of way are located, a map or maps showing the boundaries, locations and extent of said proposed rights of way, for the purposes stated in section one of this Act; but no construction work shall be commenced on said land until said map or maps have been filed as herein provided and approved by the Secretary of the Interior: **Provided, however,** That any changes of location of said rights of way may be made by said City of Los Angeles, within two years after the filing of said map or maps, by filing such additional map or maps as may be necessary to show such changes of location, said additional map or maps to be filed in the same manner as the

original map or maps; and the approval of the Secretary of the Interior of said map or maps showing changes of location of said rights of way shall operate as an abandonment by the City of Los Angeles to the extent of such change or changes, of the rights of way indicated on the original maps: **And provided further,** That any rights inuring to the City of Los Angeles under this Act shall, on the approval of the map or maps referred to herein by the Secretary of the Interior, relate back to the date of the filing of said map or maps with the register of the United States Land Office as provided herein.

Sec. 3. That the rights of way hereby granted shall not be effective over any land upon which homestead, mining or other existing valid claims shall have been filed or made until the City of Los Angeles shall have procured proper relinquishments of all such entries and claims, or acquired title by due process of law and just compensation paid to said entry men or claimants and caused proper evidence of such fact to be filed with the Secretary of the Interior: **Provided, however,** That this Act shall not apply to any lands embraced in rights of way heretofore approved under any Act of Congress, nor affect the adjudication of any pending applications for rights of way by the owner or owners of existing water rights, and that no private right, title, interest or claim of any person, persons or corporation, in or to any of the lands traversed by or embraced in said right of way shall be interfered with or abridged, except with the consent of the owner or owners or claimant or claimants thereof, or by due process of law, and just compensation paid to such owner or claimant.

Sec. 4. That the City of Los Angeles shall conform to all regulations adopted and prescribed by the Secretary of Agriculture governing the forest reserves, and shall not take, cut or destroy any timber within the forest reserves, except such as may be actually necessary to remove to construct its power plants and structures, poles and flumes, storage dams and reservoirs, and it shall pay to the Forest Service of the Department of Agriculture the full value of all timber and wood cut, used or destroyed on any of the rights of way and lands within forest reserves hereby granted: **Provided, further,** That the city shall construct and maintain in good repair bridges or other practicable crossings over its rights of way within the forest reserves when and where directed in writing by the Forester of the United States Department of Agriculture, and elsewhere on public lands along the line of said works as required by the Secretary of the Interior; and said grantee shall, as said water works are completed, if directed by the Secretary of the Interior, construct and maintain along each side of said right of way a lawful fence as defined by the laws of the State of California, with such lanes or crossings for domestic animals as the aforesaid officers shall require: **Provided further,** That the City of Los Angeles shall clear its rights of way within forest reserves of any debris or inflammable material as directed by the Forester of the United States Department of Agriculture: **Provided further,** That the said city shall allow any wagon road which it may construct within forest reserves to be freely used by forest officers and the officers of the Interior Department and by the public, and shall allow to the Forest Service of the United States Department of Agriculture and to the officers of the Interior Department, for official business only, the free use of any telephones, telegraphs or electric railroads it may construct and maintain within the forest reserves or on the public lands,

together with the right to connect with any such telephone lines, private telephone wires for the exclusive use of said Forest Service or of the Interior Department: **And provided further,** That the Forest Service may, within forest reserves, protect, use and administer said land and resources within said rights of way under forest reserve laws and regulations, but in so doing must not interfere with the full enjoyments of the right of way by the City of Los Angeles: **And provided further,** That in the event that the Secretary of the Interior shall abandon the project known as the Owens River project for the irrigation of lands in Inyo County, California, under the Act of June seventeenth, nineteen hundred and two, the City of Los Angeles, in said State, is to pay to the Secretary of the Interior, for the account of the reclamation fund established by said Act, the amount expended for preliminary surveys, examinations and river measurements, not exceeding fourteen thousand dollars, and in consideration of said payment the said City of Los Angeles is to have the benefit of the use of the maps and field notes resulting from said surveys, examinations and river measurements, and the preference right to acquire at any time within three years from the approval of this Act any lands now reserved by the United States under the terms of said Reclamation Act in connection with said project, necessary for storage or right of way purposes, upon filing with the register or receiver of the Land Office in the land district where any such lands sought to be acquired are situated a map showing the lands desired to be acquired, and upon the approval of said map or maps by the Secretary of the Interior and upon the payment of one dollar and twenty-five cents per acre to the receiver of said Land Office, title to said land so reserved and filed on shall vest in said City of Los Angeles, and such title shall be and remain in said city only for the purposes aforesaid, and shall revert to the United States in the event of the abandonment thereof for the purposes aforesaid: **Provided, however,** That the terms of this Act shall not apply to any lands upon Bishop Creek or its branches in said County of Inyo.

Sec. 5. That all lands over which the rights of way mentioned in this Act shall pass shall be disposed of subject to such easements; **Provided, however,** That if construction of said water works shall not have been begun in good faith within five years from the date of approval of this Act, or if after such period of five years there shall be a cessation of such construction for a period of three consecutive years, then all rights hereunder shall be forfeited to the United States.

Sec. 6. That the City of Los Angeles is prohibited from ever selling or letting to any corporation or individual, except a municipality, the right for such corporation or individual to sell or sublet the water sold or given to it or him by the city.

Sec. 7. That the right to amend, alter or repeal this Act at any time is hereby reserved.

Approved June 30, 1906.

APPENDIX D.

INVESTIGATION OF THE HYDROGRAPHY OF OWENS VALLEY FOR THE PURPOSE OF DETERMINING THE AMOUNT AND MOST EFFICIENT METHOD OF HANDLING THE WATER SUPPLY AVAILABLE FOR DIVERSION BY THE LOS ANGELES AQUEDUCT.*

By C. H. Lee.

The growth of the City of Los Angeles has been a phenomenal one. During the last four years the population has doubled and is at the present time about 240,000. Diagram 1 has been prepared from such reliable data as is available, to show the increase of population during the past 26 years and forecast its growth for the next nineteen years. Los Angeles is still a young city and there are so many uncertain factors which may or may not influence its future growth that it is almost impossible to make any estimate at all. It is thought that the present rate of increase of 36,700 per year is in excess of the probable future rate and a more conservative estimate has been made of 25,700 per year. This will make the population 700,000 in 1925, while the present rate, if continued, would bring it to 925,000 in the same year.

As with all American cities, the question of obtaining adequate water supply is one which is ever present. The problem which Los Angeles has to meet is especially grave, located as it is in a semi-arid country, where the sources of water supply are meager and the per capita rate of consumption large. Its present supply is fast becoming insufficient to meet the demands of a rapidly increasing population, as can be seen by consulting the Third and Fourth Annual Reports of the Water Commissioners.

There is a rather unique feature about the monthly variation in the consumption of water by the City of Los Angeles. Throughout the summer months, from May to the commencement of the rainy season, the rate is high and is sustained with remarkable uniformity. At the commencement of the rainy season it drops and remains fairly uniform until the following May. As the city does not depend to any extent on storage, but on the surface and underground flow from the San Fernando Valley, the adequacy of the supply in the past has been judged by a comparison of the summer flow of the Los

*Diagrams relative to hydrography given in body of this report apply to this report and were prepared by Mr. Lee.

Angeles River with the summer consumption rate. On Diagram 2 will be found plotted the total daily summer consumption for the years 1901 to 1906, inclusive. By comparison with the population curve it will be found that the per capita daily rate has been decreasing during this period from over 210 gallons in 1901 to 190 gallons in 1906, as the result of partial metering. It is estimated that the per capita daily rate can be reduced to as low as 150 gallons by thorough metering. On the basis of a population of 700,000 in 1925, and the present and estimated future per capita daily rate of consumption, the curve has been projected into the future. If the present rate continues the total daily consumption in 1925 will be 133,000,000 gallons or 87,000,000 gallons in excess of the present daily consumption. Expressed in second-feet this means that an additional summer flow of 135 second-feet will be required. The more conservative rate of 150 gallons per capita per day will require an addition of 91 second-feet for a population of 700,000 people.

The problem is further complicated by the existence of several suburban towns of considerable size in the vicinity of Los Angeles whose present water supplies are already inadequate and which soon must look to the city for help. In addition to the demands of an urban population, there are lying idle in the vicinity of the city about 190,000 acres which could be profitably cultivated with the application of water. It is estimated in the Fourth Annual Report of the Water Commissioners that this area would require a continuous flow throughout the year of 525 second-feet. The report also estimates the demand of Pasadena and Hollywood in 1925 at 14 second-feet continuous flow. To meet these various demands there would be required a continuous flow of 674 second-feet.

A thorough study of the various sources of supply within a radius of 100 miles of the city has been made, account of which may be found in the Fourth Annual Report of the Water Department. The conclusion there reached is that there is no supply in Southern California which wise economy would allow the city to draw upon, even if there were one of sufficient size to permanently supply its wants, which is not the case. If the city is to continue its present rate of growth, therefore, or even grow at all, water must be obtained beyond the mountain boundaries of Southern California. The nearest of such sources is Kern River, all of the flow of which is already used in the development of power and the irrigation of the rich Kern delta lands.

The only possible adequate supply which remains within reach of the city is the flow of the Owens River and its tributaries. The following report is a study of the topographic and hydrographic features of the Owens Valley in so far as they will influence the city's supply, and the development of a general scheme for handling the waters available for diversion.

GEOGRAPHY.

The Owens Valley is situated in East Central California in the counties of Mono and Inyo. It has a general north and south trend and extends from the low Deadman Divide just south of Mono Lake to a point about 10 miles south of Owens Lake. It lies between two parallel ranges of high mountains, the Sierra Nevada on the west and the White, Inyo and Coso on the east. The valley proper has a length of about 80 miles, a maximum width of eight miles and approximate area of 400 square miles.

TOPOGRAPHY.

The average elevation of the floor of the valley is 3900 feet, with a grade from Bishop to Owens Lake, a distance of 75 miles, of 11 feet to the mile. North of Bishop the grade is much steeper. A striking feature of the valley topography is the precipitous slope with which the paralleling mountain ranges rise from the valley floor to elevations of 10,000 to 14,000 feet. This is especially marked on the west, where the crest of the range has an average height of 12,000 feet, more than 40 peaks of which exceed an elevation of 13,000 feet, of which the highest is Mt. Whitney with an elevation of 14,500 feet. The difference in elevation of Mt. Williamson and the nearest point in the valley trough, which is 12 miles distant, is 10,660 feet. On the east the average elevation of the crest is 10,000 feet, with slopes almost as precipitous as those on the opposite side of the valley.

DRAINAGE.

The drainage system of the Owens Valley is best studied in relation to the controlling feature of the topography of California south of the Mount Diablo Meridian; namely, the Sierra Nevada Mountains. The range formerly existed as a more or less horizontal panaplane. During a great geological upheaval of past ages an immense crustal block was tilted up, reaching its greatest elevation along a line of faulting represented by the Owens Valley. (For detailed geological study of Owens Valley, see Water Supply and Irrigation Paper, No. 181.) Ages of weathering and erosion, both of glaciers and water, have left the range in its present state. A typical cross-section from west to east through Independence shows a gradual rise from the San Joaquin Valley to the crest, a distance of about 60 miles, of 12,000 feet, followed by a sudden drop to 9500 feet in the next 12 or 15 miles to the level of Owens Valley. The ample precipitation on the higher elevations, amounting to more than 50 inches, gives rise to numerous streams which in general take a direction at right angles to the trend of the range and flow in parallel lines to two main trunk streams which in turn are both parallel to the trend of the range. The latter are known as the San Joaquin and Owens Rivers and flow in valleys of the same names, one northerly into San Francisco Bay, the other southerly into Owens Lake. Both rivers are thus characterized by having a series of tributaries entering normally from their right bank at a fairly uniform interval, but those entering Owens River are small and more closely spaced than similar tributaries on the other side of the range. The principal tributaries of Owens River are South Branch and Rock, Pine, Bishop, Big Pine, Tinemaha, Taboose, Oak, Shepard, Independence, Lone Pine and Cottonwood Creeks. They are all torrential in character, flowing through deep narrow gorges on the higher slopes and emerging lower down on to detrital cones which they have deposited. The run-off from the east into the valley is very intermittent and practically negligible. As will be seen by a glance at a general map of California (Diagram 3), the headwaters of Tuolumne, Kern, Kaweah, Kings, San Joaquin and Merced Rivers drain the same crest which tributaries of Owens River drain.

RAINFALL.

The Sierra Nevada Mountains, in addition to controlling the drainage lines of this region, are also an important factor in rainfall distribution. The storms

occurring on the Western Coast of North America have their origin in the area of low pressure existing over the North Pacific Ocean. In general their frequency of occurrence and magnitude depend on the proximity of this area to the coast line, and in the case of the region under consideration, upon the position of its southern limits. Individual storms, if they do not pass east over Washington, Oregon and Northern California, travel on down the coast in a southeasterly direction. The Sierras seem to act as a barrier to their general eastern direction and the storm center continues southward until out of their influence. As these storms reach up on to the cool slopes of the Sierra, condensation occurs, resulting in a greatly increased precipitation which varies quite closely with the elevation. A cross-section of California normal to the trend of the Sierra passing through the towns of Monterey, Merced and Hawthorne, Nevada, upon which have been plotted the mean annual rainfall in inches at various elevations, shows this very clearly. It also emphasizes the fact that the run-off of Owens River tributaries is derived entirely from the precipitation upon and just east of the crest of the Sierra. This all occurs in the form of snow and expressed as an equivalent depth of rainfall, would probably exceed 50 inches per annum. Precipitation in the Owens Valley is very light and is largely from detached local storms. The study of rainfall in relation to the run-off of the Owens Valley can best be made, therefore, west of the crest of the Sierra Nevada Mountains. For this purpose the various stations at which precipitation records are available have been grouped as follows: Valley Group, containing all representative stations situated on the east side of the San Joaquin Valley from Stockton to Bakersfield; Foothill Group, containing similar stations in the West Sierra foothills from Oleta to Kernville; Tehachapi Mountain Group, containing stations on the line of the S. P. Ry. from Caliente to Mohave and also Ft. Tejon; and the Owens Valley Group, containing all stations in that region. For reasons obvious to any one who has studied rainfall and run-off in regions characterized by distinctive wet and dry periods, the rainfall records have all been computed by seasons extending from September 1st to August 31st, and it is assumed that the rainfall of a season produces the run-off of the following calendar year. For the purpose of comparing the rainfall at the various valley and foothill stations, the mean seasonal rainfall at each station for the period of observation has been obtained. The per cent variation of the rainfall at each station from this mean was then computed for each season. It was found that their percentages showed a remarkable uniformity. A mean of the percentages for all stations in each group was obtained for each season, therefore, and plotted on Diagram 5. Comparison of the two groups also shows considerable uniformity and gives weight to the supposition that precipitation in the high Sierras has a seasonal variation similar to that of the lower slopes and valley. The Tehachapi and Owens Valley groups have only a general similarity to the above groups and the latter especially is quite erratic, due probably to local storms of great intensity which occur in summer.

EVAPORATION.

The rate of evaporation is an especially important item in the study of the proposed conduit, on account of the loss which will occur from the large area of exposed water surface in a desert region. The great length of the conduit and the varying climatic conditions as regards temperature, humidity

and wind movements, which are encountered, make it difficult, however, to determine this loss. In Table 1 will be found all evaporation records which have been made at points in the general vicinity of the conduit and having similar climatic conditions. In addition, the following data has been obtained: The mean yearly depth of evaporation at Sweetwater Reservoir, near San Diego, Cal., for eight seasons, 1889-1896 and 1897-1898, is 4.5 feet, and a mean for several years from the surface of Owens Lake about the year 1895 is said to be 6.5 feet. Computations made on the inflow and observed variation of surface level of Owens Lake during 1904 indicate a slightly larger amount, however. The lake level has lowered 16 feet from 1894 to 1904, inclusive. During 1902, 1903 and 1904, it has lowered at the rate of 2.5 feet per year. The area of water surface exposed late in 1904 was 75 square miles. Assuming that the mean exposed area for the year was 80 square miles, the total loss by subsidence was $80 \times 640 \times 2.5 = 128{,}000$ acre-feet. The Government measurement of waste water passing Citrus during 1904 was 221,970 acre-feet, and there is little loss between here and the lake. The total evaporation loss was, therefore, 349,970 acre-feet, which expressed in depth over the mean exposed surface is 6.8 feet.

TABLE 1.

Evaporation at Various Places Having Climatic Characteristics Similar to Those Encountered on the Conduit Line.

Month.	Bishop. Year. 1904. Feet.	Palmdale. Year. 1898. Feet.	Yuma. Year. 1904. Feet.	Lake Tahoe.* May 1900 to Dec. 1901. Feet.	Kings River at Kingsburg. Nov. 1881 to Nov. 1885. Feet.
January	.349	.246‡	.300	.073	.066
February	.184	.271‡	.375	.058	.101
March	.373	.541‡	.515	.064	.204
April	.534	.667‡	.780	.104	.213
May	.933	.790	.828	.177	.281
June	.657	.890	.843	.298	.483
July	.580	.933	.850	.333	.628
August	.436	.833	.657	.485	.721
September	.319	.983	.533	.300	.541
October	.235	.542	.586	.200	.339
November	.211‡	.271	.368	.145	.176
December	.212‡	.246	.159	.115	.099
Total	5.00	7.213	6.794	2.352	3.851

It has been assumed that the record at Palmdale, located near the conduit line in the Antelope Valley, is applicable from the diversion point to the Sierra Madre Mountains, and the Sweetwater record at the Fernando Reservoirs. The former is amply large, as a glance at the table shows, and the latter is the best record available for San Fernando Valley conditions. For purposes of computing the total evaporation loss from conduit and reservoirs the following assumptions are made:

*Checked by observations on inflow and outflow.
‡Estimated.

1. The canal will be uncovered throughout its entire length.

2. The mean surface exposed to evaporation at Haiwee is that for a two-thirds reservoir capacity, that at Fernando from a full reservoir.

3. The length from conduit heading to Haiwee Reservoir = 60 miles.

4. Length of conduit, Haiwee to Fernando Reservoirs = 140 miles.

5. Average width of exposed water surface in conduit = 15 feet.

The areas from which evaporation loss occur are, therefore:

Conduit from Heading to Haiwee	=	109 acres.
Conduit Haiwee to Fernando	=	254 acres.
Haiwee Reservoir	=	1424 acres.
Fernando Reservoir No. 1	=	480 acres.
Fernando Reservoir No. 2	=	500 acres.

As the necessary conduit capacity below Haiwee should be as small as possible, the total exposed water surface has been assumed to be separated into two parts by the dam at the lower end of Haiwee Reservoir. The area of the upper section is 1533 acres; the effective area of the lower one exposed to a seven-foot yearly evaporation is 884 acres, obtained by reducing the total area of Fernando Reservoirs Nos. 1 and 2, by the factor 4.5 ÷ 7 and adding to the conduit area. Using the evaporation depth under desert conditions given in Table 2, and the above areas, the last four columns of this table have been computed. These quantities will be useful later.

TABLE 2.

Assumed Depth of Evaporation in Desert Areas Traversed by Conduit and Resulting Loss From an Effective Exposed Water Surface of 2417 Acres Formed by Conduit, and Haiwee and Fernando Reservoirs.

Month.	Depth of Evaporation. feet.	Evaporation loss from total water surface. acre-ft.	second-ft.	Evaporation loss from 60 mile canal and Haiwee R. sec.-ft.	140 mile canal and Fernando R. sec.-ft.
January	.25	604	10	6	4
February	.25	604	11	7	4
March	.50	1,208	19	13	6
April	.65	1,570	26	17	9
May	.75	1,812	29	19	10
June	.90	2,175	36	23	13
July	.90	2,175	34	22	12
August	.90	2,175	34	22	12
September	.85	2,054	34	22	12
October	.55	1,330	21	14	7
November	.25	604	10	6	4
December	.25	604	10	6	4
Total	7.00	16,915			
Mean			23	15	8

HYDROGRAPHY.

Knowledge of the flow of Owens Valley streams is very meager, previous to the time that the United States Geological Survey began systemtic measurements in connection with a Reclamation Project. The best that can be done is to study the measured and estimated flow of streams having adjacent water sheds.

During August, 1903, stations were established on Owens River, Rock Creek and Pine Creek at Round Valley, Bishop Creek at Bishop and all canals in the Owens Valley. In November a station was established on the Owens River at Citrus to measure the waste water flowing into Owens Lake, and in December one on Big Pine Creek. In addition to these regular stations, occasional measurements were made on the more important creeks, including Horton, McGee, Birch No. 1, Baker, Birch No. 2, Tinemaha, Taboose, Division, Goodale, Eight Mile, Oak, Independence, Shepard, Georges, Lone Pine, Tuttle, Cottonwood and Ash Creeks. These stations were continued until December 31, 1905, after which date all were abandoned but Owens River at Round Valley, Rock, Pine and Bishop Creeks.

The city proposes to head its conduit on the right bank of the Owens River two miles south of Charley's Butte. The streams logically available for diversion are, therefore, Owens River at that point, which includes waste water and the diversion of Stevens and East Side Canals; and all creeks from Taboose to Ash inclusive. During 1906 the city has made measurements on all these streams and from June to September, inclusive, on Owens River at Citrus. The accompanying Tables, Nos. 3-6, show the results of all measurements to date. It will be noted that the discharge of Owens River at Citrus and of the two canals diverting below Charley's Butte are all given, so that the discharge at the latter point can be easily computed.

TABLE 3.

Estimated Mean Monthly Discharges in Sec.-Ft. for the Year 1904 of Streams Entering Owens River From Taboose to Ash Creeks, Inclusive.

Streams.	Jan.	Feb.	Mar.	Apr.	May.	Jne.	Jly.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean.
Stevens Canal...	00	20	21	22	22	(22)	(22)	(15)	11	8	3	3	14.1
East Side Canal.	19	24	30	32	34	52	47	40	44	39	40	00	33.5
Black Rock Sp..	18	18	18	18	18	18	18	18	18	18	18	18	18.0
Division Creek..	1	1	2	2	4	8	6	5	4	5	4	4	3.8
Cottonwood Ck.	8	8	10	20	20	80	50	15	10	10	10	10	22.5
Total*	46	71	81	94	118	180	143	93	87	80	75	35	
Taboose	3	3	3	4	6	25	15	10	5	4	3	3	7.0
Goodale	1	1	2	6	7	11	6	4	2	2	2	2	3.8
Eight Mile.....	1	1	1	2	3	5	4	2	2	3	4	5	2.8
Oak	10	10	10	10	15	30	20	15	12	10	12	8	14.4
Independence ..	2	2	3	4	20	40	25	10	8	8	4	4	10.8
Shepard	1	1	2	2	2	30	15	8	6	4	2	2	6.2
Moffit	1	1	1	2	4	12	10	8	1	1	1	1	3.5
Georges	1	1	1	2	4	25	15	4	3	2	2	2	5.2
Lone Pine.....	3	3	4	4	6	30	20	10	6	4	3	3	8.0
Tuttle	3	3	3	4	4	20	15	8	2	2	2	2	5.7
Ash	1	1	1	1	3	15	5	3	2	1	1	1	2.9
Total	27	27	31	41	74	243	150	82	49	41	36	33	
Grand total‡....	73	98	112	135	192	423	293	175	136	121	111	68	162

* = Case 1 of diagrams. ‡ = Case 2 of diagrams.

TABLE 4.

Estimated Mean Monthly Discharges in Sec.-Ft. for the Year 1905 of Streams Entering Owens River From Taboose to Ash Creeks, Inclusive.

Streams.	Jan.	Feb.	Mar.	Apr.	May.	Jne.	Jly.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean.
Stevens Canal...	3	3	11	5	20	50	50	19	22	20	10	8	16.0
East Side Canal.	31	27	31	31	32	35	31	24	15	15	12	6	24.2
Black Rock Sp..	18	18	18	18	18	18	18	18	18	18	18	18	18.0
Division Creek..	4	3	2	2	4	6	4	3	2	2	4	5	3.5
Cottonwood Ck.	8	7	5	4	15	50	30	15	5	5	4	5	13.6
Total*	64	58	67	60	89	159	133	79	62	60	48	42	
Taboose	3	3	2	2	5	15	12	7	4	4	4	5	5.5
Goodale	3	2	2	2	5	9	6	4	2	1	1	1	3.2
Eight Mile.....	3	2	1	1	2	4	2	2	1	1	1	3	1.9
Oak	6	6	6	6	10	30	20	14	10	8	10	6	11.0
Independence ..	4	3	3	3	10	44	24	11	5	3	4	4	9.8
Shepard	2	1	1	3	7	12	7	4	2	1	2	2	3.7
Moffit	1	0.5	0.5	1	3	7	4	2	0.5	0.5	0.5	1	1.8
Georges	2	2	1	2	5	18	7	4	2	1	1	1	3.8
Lone Pine.....	3	2	2	2	5	30	30	15	4	3	3	2	8.4
Tuttle .....,	2	1	1	2	4	11	11	5	3	3	3	5	4.2
Ash	1	1	0.5	1	2	8	2	1	0.5	0.5	0.5	1	1.6
Total	30	23.5	20	25	58	188	125	69	34	26	30	31	
Grand total‡....	94	81.5	87	85	147	347	258	148	96	86	78	73	132

* = Case 1 of diagrams.

‡ = Case 2 of diagrams.

TABLE 5.

Estimated Mean Monthly Discharges in Sec.-Ft. for the Year 1906 of Streams Entering Owens River From Taboose to Ash Creeks, Inclusive.

Streams.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
Stevens Canal*							15.0	15.0	15.0				
East Side Canal*.....							26.0	20.0	20.0				
Black Rock Sp.....18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	
Division Creek 6.7	5.1	6.0	6.0	7.0	8.4	17.4	14.3	10.9	12.6	11.5	10.0	9.7	
Cottonwood Creek ... 6.1	7.1	13.7	24.2	114.0	333.0	225.0	104.0	42.0	16.0	13.3	12.4	75.9	
Total‡ 31.0	30.0	38.0	48.0	139.0	359.0	301.0	156.0	96.0	(50.0)	42.8	40.0		
Taboose 3.5	2.8	3.6	12.2	10.4	21.8	46.0	26.0	15.0	3.7	3.0	3.0	12.6	
Goodale 2.0	1.0	1.0	3.5	6.3	11.2	19.0	6.4	5.9	5.6	5.3	4.3	5.9	
Eight Mile 3.0	2.7	3.7	3.4	4.3	7.6	16.3	12.6*	9.8*	6.7	5.0	5.0	6.7	
Oak 6.0	7.5	7.8	11.9	28.0	70.0	135.0	74.0	32.0	18.0	12.0	11.0	34.4	
Independence 4.0	2.8	4.8	8.0	30.0	96.0	127.0	54.0	23.0	12.0	7.0	5.0	31.1	
Shepard 2.0	2.0	2.0	9.0	26.0	62.0	104.0	63.0	9.0	25.0	0.5	3.0	25.6	
Moffit 1.0	1.0	1.0	3.2	12.0	31.0	30.0	13.4	4.3	2.2	1.0	0.5	8.4	
Georges 1.0	1.0	2.0	5.8	21.0	53.0	87.0	42.0	21.0	7.7	2.6	1.7	20.5	
Lone Pine 3.0	2.9	3.8	7.2	28.0	74.0	129.0	59.0	27.0	14.0	8.0	8.0	30.3	
Tuttle 5.0	4.8	4.3	5.4	11.1	26.0	54.0	33.0	14.2	9.5	9.0	8.0	14.5	
Ash 1.7	3.2	4.5	8.3	14.8	30.6	25.3	5.8	4.0	3.0	2.5	2.2	8.4	
Total 32.0	32.0	38.0	78.0	192.0	484.0	773.0	390.0	157.0	85.4	55.9	51.7		
Grand total¶ 63.0	61.9	76.2	126.0	331.0	843.0	1074.0	546.0	253.0	(135.0)	98.7	92.1		

* = Measurements made at Charlies Butte January to June inclusive and October to December include these canals.

‡ = Case 1 of diagrams.

¶ = Case 2 of diagrams.

TABLE 6.

Estimated Monthly Discharge of Owens River at Citrus for Years 1904, 1905 and 1906.

Month.	Year 1903. Discharge in s. f. Max.	Min.	Mean.	Total in acre-feet.	Year 1904. Discharge in s. f. Max.	Min.	Mean.	Total in acre-feet.
January ...					300	280	290	17,851
February ..					372	187	268	15,387
March					585	195	290	17,823
April					472	2	160	9,552
May					385	2	77	4,720
June					790	210	572	34,064
July					585	165	350	21,521
August					510	230	318	19,553
September ..					385	35	125	7,438
October					560	360	451	27,731
November ..210	127	184	10,949		410	360	388	23,088
December ..280	202	236	14,511		410	335	378	23,242
The year..					790	2	306	221,970
	Year 1905.				**Year 1906.§**			
January ...418	282	369	22,690		*575	*250	*415	25,517
February ..720	376	540	29,990		*423	*288	*339	18,827
March 508	301	(383)	(23,560)		*664	*261	*422	25,948
April .....(289)	(99)	(167)	(9,940)		*486	*193	*368	21,898
May .....(99)	(49)	(70)	(4,300)		*260	*137	*175	10,760
June 508	(49)	(229)	(13,610)		1486	190	679	40,403
July 337	0	175	10,760		2610	1515	2183	134,226
August ....(14)	(0)	(6)	(369)		2216	730	1208	74,276
September .. 42	(14)	(22)	(1,310)		700	352	448	26,658
October 172	42	107	6,579					(20,300)
November ..233	172	219	13,030					(25,000)
December ..319	292	301	18,510					(31,350)
The year..720	0	(216)	(154,648)					455,163

*Computed by subtracting mean monthly discharge of Stevens and East Side Canals from discharge at Charlies Butte.

§Measurements made by City of Los Angeles—Jan. 1 to Oct. 31st.

Quantities in parenthesis estimated.

TABLE NO. 7.

Table of Discharge Measurements in Second-Feet of Streams Entering Owens River and Lake From Taboose Creek South. Made During 1903-1905.

Month.	Taboose.			Goodale.			Division.			Eight Mile.			Oak.			Independence.			Shepard.		
	1903	1904	1905	1903	1904	1905	1903	1904	1905	1903	1904	1905	1903	1904	1905	1903	1904	1905	1903	1904	1905
January,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
February,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
March,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
		(5)			(5)			(5)			(5)						(5)				
April,	....	4.2	....	....	6.4	....	....	2.1	....	....	2.5	....	....	....	....	....	3.3	....	....	....	....
																				(4)	
May,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1.0	....
			(14)			(14)			(14)			(14)			(15)		(24)	(15)			(15)
June,	....	....	17.8	....	....	10.4	....	....	5.9	....	....	3.3	....	....	32.0	....	40.0	47.0	....	....	15.2
			(17)			(17)			(17)			(17)			(17)			(21)			(18)
July,	....	....	12.0	....	....	5.5	....	....	3.5	....	....	2.1	....	....	17.6	....	....	19.4	....	....	.6.4
			(24)												(23)	(13)		(23)			
August,	....	....	5.0	....	....	....	....	....	....	....	....	....	....	....	11.7	8.6	....	.7.3	....	....	....
																(17)					
September,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	4.5	....	....	....	....	....
	(13)			(13)			(13)			(13)						(14)			(14)		
October,	4.8	....	....	1.7	....	....	6.6	....	....	2.5	....	....	....	....	....	4.3	....	....	2.1	....	....
			(17)						(17)						(8)			(11)			
November,	....	....	3.8	....	....	....	....	....	4.6	....	....	....	....	....	11.0	....	....	3.1	....	....	....
			(2)			(23)						(2)			(3)		(19)	(3)			
December,	....	....	4.6	....	....	1.2	....	....	5.0	....	....	5.4	....	....	5.8	....	3.5	3.7	....	....	....

Note.—The number in parenthesis above discharges indicates the day of the month.

TABLE 7.—(Continued.)

Month.	Moffit.			Georges.			Lone Pine.			Tuttle.			Cottonwood.			Ash.		
	1903	1904	1905	1903	1904	1905	1903	1904	1905	1903	1904	1905	1903	1904	1905	1903	1904	1905
January,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
February,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
March,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
April,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
May,	....	....	....	....	(4) 2.4	....	....	(4) 4.0	....	....	(5) 3.0	....	....	(5) 21.0	....	....	(5) 3.0	....
June,	....	....	(15) 9.0	....	....	(15) 24.0	....	(10) 28.0	(15) 37.0	....	....	(16) 10.8	....	(10) 30.0	(16) 91.0	....	....	(16) 10.6
July,	....	....	(18) 3.6	....	....	(18) 6.8	....	....	(19) 30.0	....	....	(19) 10.8	....	....	(19) 30.0	....	....	(19) 1.8
August,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
September,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
October,	(14) 0.3	....	....	(14) 0.3	....	....	(15) 3.8	....	....	(15) 2.5	....	....	(31) 7.6	....	....	(31) 1.2	....	....
November,	....	....	....	....	....	....	....	....	(9) 3.5	....	....	....	....	....	(10) 4.3	....	....	....
December,	....	....	....	....	....	....	....	....	(29) 2.3	....	....	....	....	....	....	....	....	....

Note.—The number in parenthesis above discharges indicates the day of the month.

The mean monthly discharge of the creeks was estimated from the occasional measurements shown in Table 7, and a knowledge of the daily variation in flow of Bishop, Pine and Rock Creeks. The accuracy of the estimate may be judged from Diagram 6, in which the mean flow for the year and the area of the water shed of each stream are plotted, assuming that the run-off per square mile of each shed is nearly uniform and that the percentage lost by seepage between the mouth of the canyon and the point of measurement is the same for each stream. This latter assumption is not strictly true, but the loss is greatest during the low stages of the streams and their flow at such times has little weight in the mean flow for the year. The following data relative to loss by seepage was obtained in the fall of 1906. Measurements were made at the mouth of the canyon and at the regular gaging station, and the per cent loss was based on the flow at the former place: Georges Creek, Oct. 30, loss 35%; Independence Creek, Sept. 11, loss 7%; Lone Pine Creek, Oct. 23, loss 17%; Oak Creek, Aug. 20, loss 32%; Taboose Creek, Dec. 8, loss 33%; Oak Creek, Nov. 19, loss 26%; Shepard Creek, Nov. 14, loss 35%. A tabulation of the drainage areas of the creeks from Taboose to Ash as obtained from United States Geological Survey topographic sheets is also given.

DRAINAGE AREAS OF CREEKS DRAINING THE SIERRA FROM TABOOSE TO ASH CREEK.

Creek.	Total Area. Square miles.	Area above 8000 feet. Square miles.
Taboose	7.1	6.1
Goodale	8.5	6.0
Division	7.0	4.4
Eight Mile	7.5	6.2
Oak	26.1	14.5
Independence	19.2	13.7
Shepard	12.5	11.6
Moffit	7.0	5.7
Georges	9.8	9.1
Lone Pine	14.0	12.6
Tuttle	8.5	7.3
Cottonwood	42.6	36.3
Ash	14.7	9.1

The creeks of this series having the most well sustained flow in low water period are Taboose, Division, Eight Mile and Cottonwood. Those having largest total yearly discharges are Taboose, Oak, Independence, Lone Pine and Cottonwood.

Diagram 7, shows graphically the daily amount of water in second-feet which could have been diverted during 1904, 1905 and 1906 from the logically available streams by a canal of the capacity suggested later in this report, and also the amount of water lost during flood periods, part of which is available for storage at Long Valley.

DISCUSSION OF MAXIMUM, MINIMUM AND MEAN YEARS.

Having only a three year record of actual stream gaugings in the Owens Valley it becomes necessary to use other means by which to determine the character of these years on the basis of a normal run-off, and also to determine what variation from the normal is possible. Preceding discussion has shown the similarity of precipitation over the adjacent water sheds draining into San Joaquin and Owens Rivers. As the topography and rock formation of the upper portions of these water sheds are similar, it is safe to assume that the variation in run-off from year to year would also be similar, since the greatest precipitation occurs in this portion of the basins. Discharge measurements have been made on the following tributaries of the San Joaquin River: Kern River, Kings River, Merced River, Tuolumne River and Stanislaus River; and the yearly mean for each stream will be found in Table 8. The tributary of the main San Joaquin River bearing the same name, drains the western portion

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TABLE 8.

Table of Mean Yearly Discharges and Their Per Cent of Variation Referred to a Long Term Yearly Mean, for San Joaquin Valley Streams Draining the Main Crest of the Sierra Nevada Mountains.

Sec.-Ft. Mean. Sec.-Ft. Mean. Sec.-Ft. Mean. Sec.-Ft. Mean. Sec.-Ft.

Year.	Stanislaus. Mean Disch. sec.-ft.	% of 13-yr. Mean.	Tuolumne. Mean Disch. sec.-ft.	% of 15-Yr. Mean.	Merced. Mean Disch. sec.-ft.	% of 9-Yr. Mean.	Kings. Mean Disch. sec.-ft.	% of 16-Yr. Mean.	Kern. Mean Disch. sec.-ft.	% of 14-Yr. Mean.
1879	1,858	113	2,082	81	1,321	95	1,769	73	503	64
1880	2,249	137	3,635	142	1,814	131	2,670	110	1,271	162
1881	2,116	129	2,894	113	1,673	120	2,562	106	1,175	150
1882	1,951	119	2,310	90	1,184	85	2,107	87	646	82
1883	1,292	79	1,984	77	1,341	96	1,733	71	627	80
1884	.....	...	.....	...	.....	...	4,728	194	.....	...
1896	1,935	118	2,342	91	.....	...	2,585	106	854	109
1897	1,835	112	3,364	131	.....	...	2,933	121	1,234	157
1898	466	28	1,182	46	.....	...	1,116	46	348	44
1899	1,299	79	2,315	90	.....	...	1,795	74	468	60
1900	1,203	73	2,160	84	.....	...	1,798	74	459	58
1901	.....	...	3,537	138	.....	...	4,296	176	1,216	155
1902	.....	...	2,022	79	1,095	79	2,089	86	764	97
1903	1,107	67	2,723	106	1,390	100	2,283	94	755	96
1904	2,875	175	3,948	154	1,621	117	2,586	106	679	87
1905	1,163	71	1,995	78	1,067	77	1,781	73	734	95
1906	.....	...	.....	...	.....	...	.....	*210	.....	...
Total...	21,349		38,493		12,506		38,831		10,999	
Mean..	1,642	100	2,565	100	1,389	100	2,427	100	785	100

* = Estimated.

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of the crest adjacent to the principal tributaries of the Owens River, but measurements are not available of its flow. Of the other streams Kings River is the most representative of Owens Valley streams and discharge measurements of its flow covering 16 years are available. On Diagram 5 will be found plotted the averaged variation from the normal of the seasonal precipitation at all stations in the valley and foothill groups, together with the percentage variation from the normal of the measured run-off of Kings River. A close similarity is observed, especially if the details of the distribution and intensity of storms occurring during each season is examined. The rainfall of the seasons for which gagings are lacking can, therefore, be used as an indication of the run-off. An inspection of the diagram shows the run-off for the year 1904 to be 106 per cent, or 6 per cent in excess of the normal; and 1905, 73 per cent, or 27 per cent below normal. An estimate of the yearly run-off of Kings River for 1906 makes the percentage 210, or twice the normal. There is thus one year of normal, one of rather small, and one of exceptionally large run-off available for accurate study. The diagram also shows that the run-off may exceed the normal by 75 per cent or more, once every six or seven years; may be as low as half the normal at nine or ten year intervals, and that years of large run-off are usually isolated, while years of small run-off often occur in groups of three. The latter fact points to the necessity of yearly regulation of the run-off, of which a study is made below under the head of "Long Valley Reservoir."

GENERAL SCHEME OF DIVERSION AND STORAGE.

The purpose which the proposed system of conduits and reservoirs known as the Los Angeles Aqueduct is to fulfill, is the delivery of the largest possible amount of the available supply of the Owens River and its tributaries at the head of the San Fernando Valley, there to be distributed for domestic and irrigation uses. The following can be stated as the factors which largely control the details of the system:

1. Available supply for successive intervals of time.

2. Delivery of as much of the available supply at the head of San Fernando Valley as wise economy in construction will allow, and in such a manner that the summer (May to October, inclusive) draft will be 5-4 and the winter draft 3-4 of the mean yearly draft.

3. Location and capacity of available storage sites to be used, (a) As yearly regulators of supply, (b) As monthly regulators of supply, (c) As Regulators of the final delivery, (d) As reserve supplies in case of accident to the main conduit, (e) As settling basins.

A statement of the supply logically available for diversion during the years 1904, 1905 and 1906, is made in Tables 3-6, inclusive.

The reservoirs available to the city for the purposes outlined above are as follows:

1. Long Valley Reservoir, on the Owens River above Round Valley. Its capacity for a 100-foot dam is 83,485 acre-feet; for a 120-foot dam, 160,000 acre-feet; for a 130-foot dam, 205,000 acre-feet; and for a 140-foot dam, 260,000 acre feet. This reservoir is well located to serve as a yearly regulator of the supply.

2. Haiwee Reservoir, on the line of the conduit 60 miles below the heading and 12 miles below Ash Creek. Its capacity for a 75-foot dam at its lower

end is 64,000 acre-feet. This reservoir commands all possible sources of supply and is near enough to the heading not to require a great length of conduit of the large capacity necessary to carry the flood flow of the streams diverted. It thus has an ideal location for a monthly regulator and settling basin.

3. Fernando Reservoirs Nos. 1 and 2, at the end of the conduit and at the head of the San Fernando Valley. Their combined capacity is 36,600 acre-feet; that of No. 1 being 15,940 acre-feet for a 120-foot dam, that of No. 2 being 20,660 acre-feet for a 130-foot dam. These reservoirs are at a mean elevation of 1200 feet and have a splendid location as distributors. In case of a serious break on the main conduit the two reservoirs, if full to start with, would furnish a 500 second-foot draft for 36 days; a 400 second-foot draft for 46 days, or a 300 second-foot draft for 61 days. Reservoir No. 1 alone, if full to start with, would furnish 500 second-feet for 16 days, 400 second-feet for 20 days and 300 second-feet for 26 days. The connecting channels between these reservoirs are as follows: From Long Valley to the conduit heading, two miles below Charley's Butte, the main channel of Owens River; from the heading to Haiwee, a canal and conduit of progressively increasing capacity, designed to pick up during a normal year as much as possible of the flood flow of the creeks from Taboose to Ash, inclusive; from Haiwee to Fernando a conduit of capacity just sufficient to carry the mean yearly draft available at the lower end of Haiwee Reservoir.

HAIWEE RESERVOIR.

In view of the fact that the necessities of the city twenty years hence can be amply supplied by one-half the total flow from sources already controlled by the city (see Diagram 9, Case 1), it is thought best to postpone the construction of the Long Valley Reservoir until some time in the future, and depend upon Haiwee Reservoir alone for regulation in the meantime. A study has, therefore, been made of the relation of supply and various assumed drafts at Haiwee Reservoir, using the discharge records of January, 1904, to September 30th, 1906, for the purpose of determining the maximum possible draft during that period.

Before going into the details of this, however, it may be stated that the inflow at Haiwee is not the total flow of the available sources of supply, for the reason that the diversion canal is not designed sufficiently large to carry the flood discharge at its crest for the normal year, but the mean monthly flow for a month which may be regarded as one of maximum flood flow in a normal year. June, 1904, has been chosen as such a month, and on Diagram 8 will be found plotted as increments the mean flow of all the logically available sources for that month, as they are encountered by the canal, and the corresponding canal capacity which will pick up the largest proportion of this supply consistent with economy in construction. There is a portion of the flood period in years of normal and above normal flow during which the canal cannot carry the total available supply and the inflow into Haiwee is limited to 900 second-feet. The limits of these periods were carefully defined in the computations upon which Diagram 9 is based. It is needless to say that the above condition would not exist with Long Valley Reservoir in operation.

The method of computation employed is one which has only recently come into use (see Report on New York's Water Supply, 1900, by John R. Freeman,

page 227), but was adopted on account of its comprehensive adaptability to varying phases of the problem. It consists of computing the aggregate discharge from the source, or sources, of supply from the beginning of a given period up to the end of each of the units of time into which the period is considered divided, and plotting these aggregates as ordinates of their corresponding abscissa on the time axis, thus forming a line termed the "Mass Curve." This curve may be used as a basis for computing necessary storage with a known draft, but in our case the reverse process will be used, namely, the determination of maximum draft from the available supply, the storage capacity being given. The discharge has been computed in terms of the acre-foot on account of its convenience and almost universal use in water supply computations in the West. The time unit was the day, since the flow of Owens River has considerable daily variation at certain times of the year, and the records are expressed as daily means. The records on the smaller streams are monthly means, so that in computing the daily inflow at Haiwee the daily means at Charlies Butte were increased by a constant amount during any given month.

The computations have been made for two cases: First, sources which the city controlled to a large extent Sept. 30th, 1906, namely, Owens River at Charlies Butte, Black Rock Springs, Division and Cottonwood Creeks; second, all logically available sources. On Diagram 9 will be found plotted the Mass Curve for both these cases. The draft first considered was that represented by the line "A," namely, 300 second-feet winter, and 500 second-feet summer draft. Starting with a reservoir full April 1st, 1904, no alarming depletion occurs until July 29th, 1905, when the reservoir goes dry. It remains thus until Nov. 28th, 1905 (122 days), during which time a deficiency of 69,000 acre-feet is accumulated. The reservoir then begins to fill and conditions are safe until the end of the period. The large deficiency occurring in a year of not excessive drought, and the loss of two-fifths the conduit capacity during one-half the year are sufficient reasons for not adopting this draft. Next, a uniform draft of 422 second-feet was tried (line B), but this gave a deficiency of 50,000 acre-feet, so was also abandoned. A maximum draft which makes it possible to tide over the dry year of 1905 without a deficiency is a uniform flow of 338 second-feet. Subtracting the evaporation loss (see Table 2) above the lower Haiwee Dam, the draft available from Haiwee is 323 second-feet, which will give a net yearly discharge of 315 second-feet available from Fernando Reservoir, or 395 second-feet summer flow and 237 second-feet winter flow.

There are the same objections to the draft represented by line "A" in Case 2 as in Case 1. The 422 second-foot uniform draft is not beyond consideration, however. Starting with an empty reservoir May 27, 1904, conditions remain satisfactory until October 7, 1905, when the reservoir goes dry, remaining thus until January 12, 1906 (94 days), the aggregate deficiency being 14,000 acre-feet. This deficiency can be met by an additional supply of 40 second-feet from July 1st, 1905, to January 12, 1906, obtainable either by pumping from the gravel fill of the Owens Valley or by storage in Long Valley as shown later. The draft from the lower end of Haiwee Reservoir is 407 second-feet, and from the lower end of Fernando Reservoirs 400 second-feet, or 500 second-feet summer or 300 second-feet winter flow. The maximum draft possible for no deficiency at Haiwee is 400 second-feet (line C). This gives a draft at the lower end of Haiwee Reservoir of 385 second-feet, and at Fernando Reservoir of 377 acre-feet, or a summer flow of 470 second-feet and a winter flow of 282 second-feet.

The domestic requirements of Los Angeles and adjacent suburban towns 20 years hence will probably not exceed one-half of the maximum safe draft of Case 1, so that the shortage likely to occur in Case 2, with a 422 second-foot gross draft and no storage at Long Valley, need not reduce the city's supply at all, and can be met by the irrigation interests through local pumping or a 6 per cent reduced use of water during the deficient season, as has been done in past years without serious loss. It is considered perfectly safe, therefore, to adopt a uniform gross draft of 422 second-feet as that available from the sources of Case 2, or their equivalent, and base the design and construction of the conduit from Haiwee to Fernando on a capacity of 410 second-feet, with the idea in view of the purchase by the city of sufficient rights to make available a supply equivalent to that of Case 2, and the ultimate construction of the Long Valley Reservoir, which is shown later in this report to be essential to the maintenance of this draft.

LONG VALLEY RESERVOIR.

It will be valuable at this time to examine the available supply at Long Valley and determine the real value of the reservoir as a yearly regulator for the system as outlined. For this purpose Table 9 has been prepared from the United States Geological Survey records of 1904, 1905 and 1906. The flow of Owens River at Round Valley is practically the same as that at the Long Valley dam site. The table shows, in the first place, that the ratios which the yearly discharge of Owens River at Round Valley and Rock, Pine, Bishop and Big Pine Creeks bear individually to their total are nearly equal for the three years mentioned; and furthermore, that the total yearly discharge of Owens River at Round Valley is practically the same as that at Citrus for normal and dry years and less in years of large run-off. Since there are no diversions from the Owens River above its junction with Rock and Pine Creeks, the latter conclusion can be interpreted to mean that the flow of Rock, Pine, Bishop and Big Pine Creeks is sufficient and can be diverted to supply present irrigation demands in the upper end of the valley in dry and normal years, and that, in years of large run-off, the supply from these streams is in excess of the irrigation demand. Therefore, the amount of water available for storage at Long Valley Reservoir is that which would pass Citrus as waste water if the city's diversion was made at Charlies Butte, minus the flow from the above four creeks not diverted in wet years.

TABLE 9.

Analysis of Total Discharge of Principal Tributaries of Owens River for 1904 and 1905.

	1904.		1905		1906.	
Streams.	Discharge in Acre-feet.	Per cent of Total.	Discharge in Acre-feet.	Per cent. of Total.	Discharge in Acre-feet.	Per Cent of Total.
Owens River at Round Valley..	208,461	55.0	156,600	55.0	260,200	48.6
Rock Creek	29,289	7.7	18,990	6.7	46,383	8.6
Pine Creek	24,634	6.5	11,990	4.2	32,361	6.0
Bishop Creek	80,989	21.5	59,580	21.0	119,801	22.2
Big Pine Creek....	35,417	9.3	38,608	13.5	*80,800	*15.0
Total‡	378,790	100.0	285,768	100.0	539,545	100.0
Owens River at Citrus	221,970	59.0	154,648	54.0	455,163	84.5

‡ = All creeks south of Big Pine are neglected. Their total would be about 10% of the totals above.

* = Estimated.

The following analysis points to the fact that this water available for storage at Long Valley Reservoir is equal to that in excess of the normal mean yearly flow at Citrus or at Round Valley. In other words, if present conditions remain constant in the Owens Valley as regards irrigation diversions, the city's proposed gross draft of 422 second-feet can be maintained permanently as long as the mean yearly flow at Round Valley is maintained at its normal value. First, the mean daily flow of the Owens River at Citrus from May 27, 1904, to January 12, 1906 (the interval of time between two empty reservoirs at Haiwee and not including a period of large run-off), was 272 second-feet. Add to this 14 second-feet, which is equivalent to the deficiency of 14,000 acre-feet at Haiwee expressed as a continuous flow for the period, and there results 286 second-feet as the mean flow for the 19 months' period elapsing between two consecutive similar reservoir phases at Haiwee. Assuming then that the available flow of the small streams from Taboose to Ash was as low in 1905 as it ever will be, the equivalent of a mean yearly flow of 286 second-feet past Citrus plus the total discharge of all creeks from Taboose to Ash, plus the diversions of the Stevens and East Side Canals, would be sufficient to sustain a continuous draft of 422 second-feet. Secondly, in the first part of this report the possibility of applying the per cent variations of the run-off from the normal of Kings River to Owens River conditions was favorably discussed. These percentages were 106 in 1904 and 73 in 1905, and the mean flow of Owens River at Round Valley for 1904 was 287 second-feet and for 1905 216 second-feet. Assuming then that the mean flow of Kings and Owens Rivers for any year bear the same ratio to the long term yearly mean for the respective stream, there results: Mean flow of Owens River at Round Valley for long term period equals 287-106 = 270 second-feet, or 216-73 = 296 second-feet, or an average of 280 second-feet, which is the probable mean flow for a normal year at that point. As a check at Citrus: 306-106 = 288 second-feet, 216-73 = 296 second-feet, giving an average of 292 second-feet. The flow of Owens River for a normal year, at Citrus and Round Valley, is thus practically equal and very close to the mean yearly flow, in excess of the discharge of the small creeks and two canals, required to sustain a gross draft of 422 second-feet.

The duty imposed upon the Long Valley Reservoir, therefore, is to maintain the mean yearly flow at Round Valley at its normal value. The only data available for an investigation of its ability to perform this duty are the run-off percentages of Kings River, the rainfall percentages of the Foothill and Valley Groups, and the record of fluctuation of the water surface of Tulare Lake (see Diagram 10). The two latter extend back to 1850. The mean yearly discharges in second-feet of Owens River at Round Valley were computed from this data for every year during the period 1850 to 1906. From them has been constructed the Mass Curve of Diagram 11. Examination of this curve shows that, neglecting the two-year period of excessive drought of 1870 and 1871, the maximum storage requirement from 1851 to 1906 is 240,000 acre-feet. As the capacity of the Long Valley Reservoir is 260,000 acre-feet for a 140-foot dam, the reservoir is competent to perform its function as a yearly regulator. The reason for neglecting the period of excessive drought of 1870 and 1871 is apparent from Diagram 10, showing fluctuation of Tulare Lake. The lowering of the lake level during those years was only five feet, while during the dry period 1863 and 1864 the lowering was eight feet, the initial elevation being 212 feet in both cases. The fluctuation of Tulare Lake depends largely on the

run-off of Kings River. It is, therefore, fair to suppose that although the rainfall record indicates an excessively dry period for 1870 and 1871, that the run-off was not proportionately small and that the period could have been tided over without a serious deficiency.

This study of the Long Valley Reservoir is not based on actual knowledge of the run-off of the streams involved, nor has there been any consideration of evaporation loss from the reservoir. For a reservoir capacity of 160,000 acre-feet which may be considered a mean, the exposed water surface is 500,000 and with an evaporation rate of three feet the loss would be 15,000 acre-feet per annum, or 21 second-feet continuous flow. Although the excess flow in wet years of Rock, Pine, Bishop and Big Pine Creeks, over and above irrigation diversions, can be stored at Haiwee, it has purposely been omitted from the above computations so as to leave a margin of safety. There is still much to be said, however, in favor of further purchase of existing water rights in the upper part of the Owens Valley, and since this report was written, considerable has been done in this direction. Table 9 shows that in 1904 the amount of water diverted by irrigation canals and entirely consumed to be 156,820 acre-feet, or 216 second-feet continuous flow; and in 1905 131,120 acre-feet, or 181 second-feet continuous flow, or a mean of about 200 second-feet. As these amounts were computed by subtracting the total discharge at Citrus from the total discharge into the valley, they represent an absolute loss. The purchase of even one-half this amount would greatly simplify the operation of the Long Valley Reservoir, as well as insure the permanent maintenance of a 422 second-foot diversion by the city.

CONCLUSION.

The complete system of reservoirs and conduits which is to be known as the Los Angeles Aqueduct will consist of (1) the Long Valley Reservoir, at the head of the Owens Valley, with a 140-foot dam; (2) the channel of the Owens River to Charley's Butte; (3) sixty miles of canal and conduit of capacity varying from 700 to 900 second-feet; (4) Haiwee Reservoir, with a 75-foot dam at the lower end; (5) 140 miles of conduit of 410 second-feet capacity; (6) Fernando Reservoir No. 1, of 15,940 acre-feet capacity with a 120-foot dam; (7) Fernando Reservoir No. 2, of 20,660 acre-feet capacity with a 130-foot dam.

The supply will consist of the Owens River at Charley's Butte as regulated by the Long Valley Reservoir plus that of all springs and streams from Taboose to Ash Creeks, inclusive, or its equivalent.

This system will be adequate to deliver from the lower end of Fernando Reservoirs a continuous flow of 400 second-feet under the most adverse conditions, with the possible exception of a dry period of two or more consecutive years, which may occur once in fifty years.

Respectfully submitted,

CHARLES H. LEE.

NOTE.—Recent surveys have shown the possibility of developing storage at the lower end of the conduit in the San Fernando Valley to the extent of 49,000 acre-feet in addition to that of Reservoirs Nos. 1 and 2. This makes

possible a summer draft of 600 second-feet and a winter draft of 200 second-feet from all the storage reservoirs at the lower end of the conduit, and would eliminate all danger of a shortage due to accident to the main conduit, even such as would result from severe earthquake shock. A flow of 500 second-feet could be maintained for three months with full reservoirs to start with.

There has also been located a storage site near Fairmont which can be utilized as a daily regulator in connection with the operation of a power plant. This will be of great value by making it possible to carry a peak load at the power house much in excess of the mean load.

CHEMICAL CHARACTER OF OWENS VALLEY WATER.

There have been numerous chemical analyses made of water in the Owens Valley, both of the main river and side streams.

The following six analyses were made of samples taken by H. C. Witmer for the Los Angeles Chamber of Commerce during July, 1905. Nos. I, III and V were submitted to Wade & Wade, of Los Angeles, and their analysis made August 31, 1905. Nos. II, IV and VI were submitted to the Department of Agriculture of the University of California. The analysis was made August 30, 1905, by George E. Colby, and approved by A. J. Wickson, Acting Director.

I.

SAMPLE FROM BLACK ROCK SPRINGS.

	Grains per Gallon.
Magnesium carbonate	1.10
Calcium sulphate	1.00
Calcium carbonate	2.30
Sodium chloride	0.80
Sodium (potassium) sulphate, traces of iron, alumina, etc	0.70
Silica	0.40
Total anhydrous mineral matter	6.30

Organic matter .....Inappreciable.

Note.—Exceptionally pure water.

V.

SAMPLE FROM CHARLEY'S BUTTE.

	Grains per Gallon.
Magnesium carbonate	2.70
Calcium carbonate	5.30
Sodium carbonate	1.30
Sodium chloride	2.60
Sodium (potassium) sulphate, traces of iron, alumina, etc	1.10
Silica	1.10
Total anhydrous mineral matter	14.10

Organic matter .....Inappreciable.

Note.—Very good water for general purposes.

III.

SAMPLE FROM LONE PINE.

	Grains per Gallon.
Magnesium carbonate	3.40
Calcium carbonate	5.20
Sodium carbonate	2.60
Sodium chloride	5.00
Sodium (potassium) sulphate, traces of iron, alumina, etc	4.10
Silica	2.00
Total anhydrous mineral matter	22.30
Organic matter	Inappreciable.

Note.—Fair water.

GENERAL CHEMICAL ANALYSIS.

	II. Owens River near Lone Pine. Grains per Gallon.	VI. Owens River Charley's Butte. Grains per Gallon.	IV. Black Rock Springs. Grains per Gallon.
Potassium sulphate, very small, and sodium sulphate (Glauber's salt), etc	7.55	5.11	1.21
Sodium chloride (common salt)	1.01	.33	.17
Sodium carbonate (sal soda)	2.22	.68	.37
Calcium and magnesium carbonates, etc	6.88	7.93	1.05
Calcium sulphate (gypsum)	2.70	.64	2.15
Silica	2.33	1.22	1.75
Organic matter, all three "char" and chem. combined water	1.05	.99	.87
Total	23.74	16.90	7.57

SANITARY ANALYSIS.

Date	Mark of Sample	Grains per gallon: Total Residue	Grains per gallon: Chlorin	Parts per million: Ammonia Free	Parts per million: Ammonia Albuminoid	Parts per million: Oxygen consumed by moist combstn	Parts per million: Nitrates N_2O_5	Parts per million: Nitrates N_2O^3
	II.							
Aug. 30.	Owens River near Lone Pine	23.74	.60	.110	.184	2.80	none	none
	VI.							
Aug. 30.	Owens River at Charley's Butte	16.90	.20	.100	.170	1.60	none	none
	IV.							
Aug. 30.	Black Rock Springs	7.57	.10	.044	.064	0.80	none	none

The following three samples were analyzed by Laird J. Stabler, of the University of Southern California:

I.

Water Taken From Lone Pine Bridge by Wm. Mulholland, March 20, 1906.

Sodium chloride	6.76 grains per gal.
Sodium carbonate	7.93 grains per gal.
Sodium sulphate	5.01 grains per gal.
Calcium carbonate	6.64 grains per gal.
Magnesium carbonate	1.16 grains per gal.
Iron and alumina	0.58 grains per gal.
Silica	0.82 grains per gal.
Total	28.90 grains per gal.
Organic matter	trace.

Note.—This sample taken at time Board of Public Works visited the valley, there being then about 500 second-feet in stream with considerable water coming in from the flats, due to recent storms.

II.

Water Taken From Black Rock Springs by Harold Eaton in March, 1906.

Sodium chloride	0.75 grains per gal.
Sodium carbonate	2.75 grains per gal.
Sodium sulphate	1.84 grains per gal.
Calcium carbonate	1.05 grains per gal.
Magnesium carbonate	.60 grains per gal.
Iron and alumina	.25 grains per gal.
Silica	.41 grains per gal.
Total	7.65 grains per gal.

III.

Water Taken From Lone Pine Bridge by Wm. Mulholland in April, 1905.

Sodium chloride	3.84 grains per gal.
Sodium carbonate	.50 grains per gal.
Sodium sulphate	4.32 grains per gal.
Calcium carbonate	1.16 grains per gal.
Calcium sulphate	6.58 grains per gal.
Magnesium sulphate	1.17 grains per gal.
Iron and alumina	1.02 grains per gal.
Silica	.55 grains per gal.
Total	19.14 grains per gal.

The following analyses are of samples taken at Round Valley from May 13th to Sept. 2d, 1906, by the Reclamation Service, and were made by Mr. F. M. Eaton, Assistant Analyst.

SAMPLES TAKEN FROM OWENS RIVER AT ROUND VALLEY BY THE RECLAMATION SERVICE WEEKLY ANALYSES.

Date. 1906.	Total Solids Susp.	Diss.	Carbonate. CO^3	Bicarbonate. HCO^3	Chlorine. Cl	Sulphate. SO^4	Laboratory No.
5, 13-19	2.8	12.0	0.00	11.15	1.90	....	3358
5, 20-26	1.0	21.4	0.00	10.20	1.50	....	3359
5, 27-31	1.8	24.6	0.00	13.70	2.47	....	3360
6, 3-9	3.4	17.0	0.00	8.29	1.98	....	3361
6, 10-16	7.0	13.0	0.00	7.65	0.99	....	3362
6, 19-23	4.0	15.4	0.00	8.79	0.49	....	3363
6, 24-30	5.2	15.4	0.00	8.79	1.98	....	3364
7, 1-7	6.4	17.6	0.00	7.97	0.99	....	3451
7, 30-8, 4.....	1.2	18.2	0.00	8.17	0.99	....	3643
8, 5-11	8.6	17.4	1.91	4.58	1.48	light	3723
8, 12-18	6.6	16.4	0.00	8.50	1.48	light	3724
8, 19-25	6.8	13.4	0.00	10.10	1.68	....	3806
8, 26-9, 1.....	7.4	11.4	0.00	10.65	1.78	....	3840
9, 2-8	1.2	16.2	0.00	9.10	1.78	light	3926

MEAN FOR EACH MONTH.

Month.	T. S.	Ca.	Mg.	Na.	SO^4	CO^3	HCO^3	Cl.	NO^3	Lab. No.
May	15.88	2.25	0.44	3.62	1.77	0.00	13.40	2.97	.0000	3398
June	15.40	2.71	0.44	2.68	1.73	0.00	9.60	0.79	.0005	3486
July	15.25	2.25	0.40	3.44	1.77	0.00	7.53	1.49	.0005	3861
August	13.65	1.86	0.64	4.41	1.90	0.00	10.80	1.55	.0010	4035

Note.—The results are reported in parts per 100,000.

APPENDIX E.

REPORT OF THE BOARD OF CONSULTING ENGINEERS ON THE PROJECT OF THE LOS ANGELES AQUEDUCT FROM OWENS RIVER TO SAN FERNANDO VALLEY.

Los Angeles, Cal., Dec. 22, 1906.

To the Board of Public Works of the City of Los Angeles:

Gentlemen: We herewith submit the following report upon the project of the City of Los Angeles for obtaining an additional supply of water from the Owens River and its tributaries.

On undertaking this work you gave us the following subjects for investigation and report:

First: To study the hydrography of the Owens River drainage basin, with special reference to its reliability as a source of water supply, from data to be furnished by you, and such other data as may be obtained from any other reliable source.

Second: To make an examination of the quality of the water at the proposed point of intake, and the possibility of its quality being affected in process of transmission to its destination.

Third: To make an examination of the route over which the proposed aqueduct is to be built, and to review any alternate lines where such may be conducive either to saving in cost, time of construction, or safety in maintenance.

Fourth: To make an examination of proposed reservoir sites, and to consider their value in regulating variation in flow from the source.

Fifth: To study the capacity of the several sections of the aqueduct with a view to making suggestions as to any alterations necessary to enable it to properly meet variable conditions of flow.

Sixth: To study the designs and materials proposed to be used in the construction of the aqueduct, with a view to making any suggestions of necessary amendments or changes.

Seventh: To estimate the cost of the aqueduct, reservoirs, and all accessories complete, from intake to point of exit in the San Fernando Valley.

Eighth: To estimate the time required to complete the entire project as outlined.

Ninth: To estimate the amount of water power that may be developed along the line.

Tenth: To make recommendations for the best executive and engineering organization for the construction of the aqueduct.

Eleventh: To prepare and submit to you, in writing, a report on all matters hereinabove specified, and any other matters pertinent to the project that this Board of Engineers may deem of importance.

In addition, we were officially informed that the time required for making the investigations and report would be approximately thirty days.

The Board convened in Los Angeles on November 14th, and has been continuously engaged upon the work to the present time. In addition to this time devoted to the work by the Board as a whole, Mr. Freeman, by request, visited Los Angeles in August for obtaining preliminary data, and Mr. Schuyler made two trips over the aqueduct in October, making suggestions as to material changes in the route which have met with our unanimous approval.

These preliminary examinations have greatly facilitated the subsequent proceedings of the Board.

EXAMINATIONS.

After devoting the 14th to a study of the plans, November 15th was given chiefly to an examination of the Los Angeles River, the San Fernando Valley and the reservoir sites therein.

On the following day a start was made over the territory in question in automobiles from Saugus, accompanied by the chief engineer, Wm. Mulholland, and principal assistant engineer, J. B. Lippincott, on a trip of eleven days' duration which extended to the Long Valley reservoir site in the northerly part of the Owens River Valley. During this examination we inspected the various streams which flow into Owens River; examined and sampled the water of Owens River at three places; investigated the Haiwee reservoir site and also the line of the aqueduct from the proposed point of diversion on Owens River, all the way to the San Fernando Valley. Eight days were spent in the examination of the aqueduct line, much of the time in walking over the line, especially at the more important points.

CAPACITY OF SOURCES OF SUPPLY.

Measurements of the flow of Owens River and its tributaries were made by the United States Geological Survey for two years beginning in August, 1903, and measurements of the flow of the river have been continued during the past year by the City of Los Angeles. There are, therefore, now available measurements of the run-off for three years, which fortunately include a normal year, a dry year and a very wet year. By comparing these measurements with others on the adjoining westerly slope of the Sierras, where records of the rainfall and stream flow for a period of sixteen years are available, it is possible to deduce by analogy the extremes of minimum discharge which may occur in the river and its tributaries during seasons of more acute drouth than the driest of the three in which measurements have been recorded.

After a study of all of these measurements, and of the computations which have been made, we are in agreement with the report submitted to us by the engineers of the Los Angeles Aqueduct that 410 cubic feet per second of water can be depended upon with the regulation of the Haiwee reservoir alone in years similar to those in which measurements have been made upon the Owens River, and that with the further aid of the Long Valley reservoir the 410 cubic

feet per second of water can be depended upon in years as dry as any that have occurred upon the adjoining watersheds in the past sixteen years.

We have not thought it necessary to attempt to determine just how much water has already been acquired by the City of Los Angeles, but from the information given us, it is plainly a large proportion of the quantity above named and sufficient for all probable needs for several years after the completion of the aqueduct. Moreover, it is expected that additional water-rights will be obtained before the completion of the aqueduct.

QUALITY OF WATER.

We have visited the river at the proposed intake of the aqueduct, and one member of this Board on October 25, 1906, took a sample of water from the river at the bridge next below the point of intake. This water has been analyzed, and a copy of the analysis follows:

UNIVERSITY OF SOUTHERN CALIFORNIA.

Laird J. Stabler, Professor of Chemistry.

Los Angeles, Cal., Nov. 28, 1906.

Mr. J. D. Schuyler, Los Angeles, Cal.:

Dear Sir: I have analyzed the sample of water delivered by you in a sealed package with the following result:

	Per gallon.
Sodium chloride	2.10 grains
Sodium and potassium sulphate	2.21 grains
Sodium carbonate	3.38 grains
Calcium carbonate	4.66 grains
Magnesium carbonate	1.02 grains
Iron and Alumina	.56 grains
Silica	.82 grains
	14.75 grains

This is good water for domestic purposes. The alkali forming salts are small, consequently it is good for irrigating purposes. The lime and magnesia salts are present in small quantity; this fact shows the water would not form a bad scale if used in boilers. The water would be fairly soft for laundry purposes.

Yours truly,

(Signed.) LAIRD J. STABLER.

We have been furnished with many additional analyses showing the quality of the water of the Owens River and its tributaries, and of the water now supplied to the City of Los Angeles. A comparison of these shows that the Owens River water is much softer than the water now supplied to the city, which contains from two to three times as much dissolved mineral matter as the water of Owens River. Our examination of the streams in the Owens Valley showed that the creeks coming from the Sierras furnished water which is clear, colorless and attractive; the water in the river being made up of the combined flow of these creeks is of similar character, but has a slight turbidity

and stain owing apparently to drainage from the marshes in Long Valley and to other return water from the canals and irrigated lands. This feature would make the water somewhat objectionable if it were to flow directly from the river into the city pipes; and it has little or no significance in the present instance, where the water, after being taken from the river, is to be held for a long time in a large storage reservoir, where the particles which produce the turbidity will have time to settle. The long period of storage in the reservoir will also be an important safeguard against the transmission of disease germs should any enter the water of the river, because it has been found both by experiment and experience that disease germs are all or nearly all destroyed, where the water is held sufficiently long in reservoirs.

Although the storage of water in a reservoir has a favorable effect in the directions indicated, it sometimes promotes the growth of water plants or algae, which make the water less palatable and attractive; these growths are liable to occur with any water, and have very little, if any, sanitary significance. It is not feasible to prevent them, but it is feasible to remove their effects by aeration and filtration.

There is an abundance of surplus fall available for aeration below the Haiwee reservoir and in the San Francisquito Canyon, where the water will either flow for several miles down the natural bed of the stream, or be discharged with great force against impulse wheels, in either case, receiving most thorough aeration.

In our opinion, water which has thus been stored and subsequently aerated, will be of better quality at its exit from the aqueduct into the San Fernando Valley, than when taken from the Owens River.

OUTLINE OF PLAN OF WORKS.

The plan contemplates the building of an aqueduct of sufficient capacity to deliver a continuous flow of 400 cubic feet per second, or 20,000 "miner's inches" as it is locally considered and measured. Starting at the point of intake on Owens River, about twelve miles above the town of Independence, or two miles below a basaltic mound in the valley called "Charley's Butte," the main canal to the Haiwee Reservoir, a distance of sixty miles, will have a capacity of 700 to 900 cubic feet per second, starting with 700 second feet, and increasing as the side streams are crossed, until Cottonwood Creek is reached, from which point to the reservoir the capacity will be 900 second feet.

This large capacity is provided for the purpose of gathering as much of the flood discharge as is practicable, and conveying it to the main storage reservoir at Haiwee Meadows, whence it is to be drawn at a uniform rate of 400 second feet, plus an additional amount, estimated at 10 cubic feet per second, for evaporation losses en route.

For the first twenty miles through the Owens Valley, the canal will be sufficiently below the normal water plane in clayey soil of close texture, to require no lining, but for the lower forty miles from the point where it begins to skirt along the flanks of the Alabama Hills through to the reservoir, it will be lined on bottom and sides with masonry laid in Portland cement and plastered in a manner intended to prevent a loss of water, thus forming a canal of sufficient stability to withstand all ordinary vicissitudes.

The elevation of the hydraulic grade at the head-works is 3820 feet above sea-level, and the proposed high water line of the reservoir is 3760 feet, giving

a total fall of sixty feet to the canal, or an average of one foot per mile, from the intake to the Haiwee Reservoir.

AQUEDUCT FROM HAIWEE RESERVOIR TO THE SAN FERNANDO VALLEY.

From the outlet of the Haiwee Reservoir (low water elevation 3695) to Little Lake, a distance of 15.5 miles, through Rose Valley, there is a total fall of 310 feet. Under the revised plans 270 feet of this drop may be made available for power whenever the demands will justify its development. To reduce the immediate expenditure it now appears best to construct this fifteen miles in the form of an open conduit of small section lined with masonry, following the smooth ground in the Rose Valley along the steep natural gradient, thus utilizing the fall to increase the velocity of the water and lessen the size of the conduit. Whenever a demand comes for the development of power in this somewhat remote locality a new line of conduit can be built along the higher elevation following the contour of the hills at a less steep gradient, thereby saving fall for the development of power. After more complete surveys of the high line it may be found that its additional cost need not defer its construction, especially if there is a prospect of the demand in the not-distant future for the 7000 horse power which can here be developed.

From Little Lake to Indian Wells, a distance by the conduit line of 24.5 miles, is a section of more difficulties than the ordinary, as the line must be supported on the mountain sides at an elevation of 200 to 500 feet above the valley, along which the highway follows at the base of the Sierra. Here a succession of tunnels, siphon pipes and bench conduit, excavated much of the way in solid rock and covered from the outset with reinforced concrete, are required. The siphons are eight in number, having a total length of three miles, and a maximum head of 150 to 450 feet, while the tunnels have a total length of five miles.

From Indian Wells the line enters upon a section of smooth open valley land extending nearly to Red Rock Canyon, a distance of 20 miles, where the excavation will be comparatively easy, with only 3750 feet of steel flumes and siphon pipes for crossing dry washes that come from the mountains.

Beginning at the summit of the ridge dividing Indian Wells Valley from Red Rock Canyon, and extending a distance of 21.5 miles, the second difficult section of the work is encountered, requiring about eight miles of tunnels, 3.5 miles of steel flumes and siphons, and ten miles of concrete lined and covered conduit. A considerable portion of this distance, however, is through indurated clay, sand and shale, which is not difficult of excavation, although extremely broken in surface topography. In this division the line must be carried across Jawbone Canyon with a siphon pipe having a maximum head of 850 feet.

After passing this broken ground, the conduit emerges upon the smooth plains of the Antelope Valley, where a canal may be built with a minimum of cost, crossing the Southern Pacific Railroad some two miles north of Mojave, and extending entirely around the head of the valley, west of Neenach, to a point nearly south of Fairmont, where it is to discharge into a second reservoir, most conveniently located with its high water plane at an elevation of 3025 feet above sea-level. In all this distance of 64.5 miles, there are but two exceptions to the unbroken smoothness of the gently sloping plain, covering a total distance of about six miles. One of these is the crossing of Cottonwood

Creek No. 2 with some four miles of indurated sand hills immediately west of it, and the other extends for about two miles along the rolling foot hills approaching the Fairmont Reservoir on the opposite side of the valley.

From the Fairmont Reservoir it is proposed to pierce the main mountain range with the longest tunnel on the line, 25,000 feet in length, passing under Elizabeth Lake Valley between the upper and lower lakes, at a depth of 350 feet below the valley floor. The tunnel is projected to leave the Fairmont Reservoir at a depth of 75 feet below the water line, and be built as a pressure tunnel for subsequent power development.

It will emerge into San Francisquito Canyon, down which the water is to be permitted to flow a distance of about eleven miles, with a total fall of 1550 feet from the water line level of the Fairmont Reservoir, until such time as the power available from this drop is utilized and the water conveyed through conduits required to develop the power.

Picking up the water at an elevation of 1470 feet, by means of a diverting dam in the San Francisquito Canyon at the lowest narrows, the delivery to the head of the San Fernando Valley will be effected in a distance of 15.18 miles; by means of a succession of tunnels in indurated earth and sandstone aggregating 10.5 miles, with siphon across Soledad Valley having a head of but 230 feet; another across Placerita Valley with 80 feet head; some short flumes, and about 1.6 miles of covered conduit. The San Fernando mountain range is to be pierced with a tunnel nearly parallel to, but east of the Southern Pacific Railroad tunnel, and at an elevation some 40 to 60 feet lower, having a total length of 14,100 feet from portal to portal.

A study of the geological formation of the San Fernando Mountains in the neighborhood of the proposed tunnel shows that there is a marked synclinal fold about on the line of the railway tunnel where the sandstone and shale strata dip toward the line of the tunnel, and are much contorted and crushed. This would account for the fact that the railway tunnel required timbering throughout its length and that some moving ground was encountered. A short distance to the east of this line, however, it is possible to select a site for a longer tunnel which will probably be entirely in firm sandstone, and devoid of the complications incident to tunneling in the thread of a synclinal crush. It is in this firm and solid material that the aqueduct tunnel has been projected. The deep cut 50 feet or more in depth on the summit of the Fremont Pass on the wagon road to Newhall, which has stood with nearly vertical sides for more than forty years, gives a fair indication of the firm and stable material in which it is possible to locate the aqueduct tunnel, at far less cost than would otherwise be expected, were the unfavorable conditions surrounding the excavation of the railway tunnel to be taken as a criterion.

The aggregate length of the aqueduct may be summarized as follows:

	Feet.	Miles.	Per cent.
Conduit, unlined canal	117,200	22.20	9.9
Conduit, lined with rubble masonry or concrete	868,700	164.53	72.7
Tunnels, in rock	96,295	18.24	8.1
Tunnels, in earth	53,370	10.11	4.5
Siphons of steel pipe crossing canyons	47,460	8.99	4.0
Steel flumes crossing shallow and narrow depressions	9,510	1.80	0.8
Total	1,192,535	225.87	100.0

The conduit has been estimated with a cover of reinforced concrete for a distance of 100,440 feet, or 11.6% of the entire lined section, the remainder to be left open for the first five years of operation.

MODIFICATIONS OF PLAN.

In a work of this magnitude and on such bold lines, many trial routes must of necessity be surveyed, their cost estimated, and their advantages compared before the final line for construction is laid down. In an aqueduct and reservoir project more trial lines are needed than on a railroad project, because of the necessity of following a gradient along which water will flow with velocity rapid enough to prevent sedimentation, and not so rapid as to produce scour, and because of the importance of distributing the fall so as to lessen the diameter and cost of the more expensive portions of the work, and adapt to each type of ground the type of conduit best suited for utilizing the natural resources of the neighborhood in material for concrete and masonry.

Although it is now certain that the best general line of location has been reached, many local variations are still possible, and six or more months of further study by your engineers may well be devoted to this matter of final location.

This Board in its studies, and in course of conference with the engineer of the aqueduct, has been led to unanimously recommend the following important modifications:

First: The substitution of a direct line (suggested by Mr. Schuyler) via San Francisquito Canyon instead of the long detour via Acton, thus saving 20 miles in distance over a very rough country and shortening the length of the longest tunnel by about one and one-fourth miles, thus reducing the time required for the completion of the work, besides effecting a very considerable saving in cost.

Second: The substitution of a high-grade tunnel and conduit line for a siphon, of 15 miles in length, from Little Lake south, using somewhat over 100 feet of spare fall for that purpose, thereby reducing cost and increasing permanence of construction.

Third: The raising of the elevation of the entire line from Indian Wells to the Fairmont Reservoir about 60 feet at the lower end, and 110 feet at the upper end, utilizing a further amount of the surplus fall, and thus permitting the utilization of the Fairmont Reservoir for storage as a regulator of the power plants to be built on the drop in the San Francisquito Canyon.

Fourth: The elimination of the proposed siphon across Antelope Valley, 11 miles in length, with a maximum head of 400 feet, and substituting a conduit line passing around the head of the valley. This increases the total length of the aqueduct about 21 miles, but effects a saving in head at Fairmont Reservoir amounting to 60 feet, available for storage and power.

Fifth; The construction of the Elizabeth Lake tunnel next to the power drop of the larger dimensions and steeper gradient needed for developing a rate of flow in the hours of maximum power demand, two and one-half times as great as the mean rate of flow, thus largely increasing the amount of power available for sale, and for the development of manufacturing.

Sixth: We recommend that the conduit and the tunnel and pipe sections have their water-ways designed on a somewhat more liberal basis than at first proposed, in order to provide against possible increase of friction with age, or the adhesion of organic growths.

We suggest the use of the following coefficients in the Kutter formula:

For open masonry conduits of cement or smoothly plastered masonry,
n=.018

For concrete-lined tunnels, or covered masonry conduits,
n=.014

For steel pipe with rivet heads and seams projecting on the interior,
n=.016

For earth canals with bottom as left by dredging,
n=.0275

In proportioning the aqueduct between Haiwee Reservoir and the San Fernando Valley to convey a mean flow of 410 feet per second, including evaporation loss, we recommend and have based our estimates of cost upon a capacity five per cent greater, thus providing for a delivery of 430 cubic feet per second of water in order that the Fairmont or Fernando Reservoirs might be replenished within twenty days after having been depleted by the interruption of flow in the aqueduct.

In the plans as submitted to us there were several inverted steel siphons of considerable length aggregating about 33 miles. Some of these we advise should be eliminated altogether and others shortened as much as possible for reasons both of economy and durability.

There also entered into this question the consideration of the possibility of the steel market being able to afford in a reasonable time such a large order as these siphons would involve. Indeed, it may be said that cutting the distance piped down to the lowest possible distance, still leaves a tonnage that may prove troublesome to supply unless plenty of time is given the mills to fill the order.

There is an economic question involved in this matter which will, no doubt, appeal to your citizens that, with the exception of the steel in the siphons and the machinery equipment, the entire cost of building, both for material and labor, will be distributed among your own people, if the intention is carried out of producing the cement required.

After a very careful study of all the conditions in detail this Board is of the opinion that all of these changes are desirable, and recommends that they be made.

As a result of our studies, it has been necessary to make new designs of sections of the various types of aqueduct suited for the several localities, to correspond with the steeper grade and the more conservative factors allowed for frictional resistance.

RESERVOIR SITES.

The most important reservoir site on the line of the aqueduct is that to be located at Haiwee Meadows, as it affords a means of direct equalization of the flow of the main canal and the streams gathered by the canal. The reservoir is situated on a summit in the valley, from which the natural drainage is in both directions, north and south. It has a length of 7.4 miles, measured along the thread of the valley, and is to be formed by dams at each end, the south dam being the larger of the two, 70 feet in maximum height with a top length of 900 feet. The north dam is longer, but has a height of but 30 feet. Materials in the vicinity are favorable for the erection of safe, substantial dams of earth at both sites.

The capacity of the Haiwee Reservoir at the elevation of 3760 feet, as surveyed by Mr. Mulholland, is computed at 63,780 acre-feet. By building the dams 10 feet higher, this capacity may be increased to 82,350 acre-feet, a most valuable increase in storage, although requiring a diminution of the fall in the main feeder canal by 10 feet in 57 miles. The position of the canal is such that it cannot be raised at the upper end without sacrificing the flow at Black Rock Springs.

Below Black Rock Springs we find this change of gradient of the canal apparently involves no special difficulty, and we recommend that this change receive further consideration.

The Long Valley Reservoir, with a dam 140 feet high, has a capacity of 260,000 acre-feet, or 85,000,000,000 gallons in round numbers, which is several times the largest existing reservoir in the State. A study of the records of water measurements by the United States Geological Survey for three years on Owens River, and a comparison with longer records of stream flow on Kings River, on the western slope of the Sierras, indicates that when this reservoir is created, the equalization of seasons of extremely large run-off, with that of dry years, will effect a saving of water which is now lost to all useful purposes, amounting to about 80 cubic feet per second, in addition to the water controlled by the aqueduct, and owned or appropriated by the city. This addition is necessary to the ultimate securing in years of excessive drouth, of the full amount of 400 second feet, for which the aqueduct has been designed.

The Board visited the Long Valley dam-site and examined the rock formation of the canyon where the dam would have to be built. The river has cut a deep channel through a volcanic rock classed by geologists as tufa—a rock which is much lighter in weight than granite, but sufficiently strong to be relied upon as a satisfactory foundation for the construction of any type of dam which may in future be decided upon after more careful examination and study of all available materials.

In the opinion of the Board a stable and safe dam can be built at this site and the selection of the particular type to be preferred is an economic question which it is now premature to discuss or attempt to decide.

The Long Valley reservoir site, which is chiefly embraced within the limits of the lands purchased by the City of Los Angeles, is admirably adapted to the regulation of the river flow, and the substantial increase of the water supply of the aqueduct by equalizing storage, and should be considered as an essential factor in the general plan, to be developed as early in the future as may be possible. For the reason that this regulation of the river is only required when the demand has reached the maximum aqueduct capacity and to provide against a series of dry years, it has not been included in our estimates or considered as an essential feature of the system for immediate construction.

The Fairmont reservoir site, before referred to, has a capacity of 5917 acre feet, sufficient to afford a full supply of the maximum capacity of the conduit for nearly eight days. As an insurance against interruptions during the cleaning or repairs on the long line of aqueduct above it, maintaining the power plant in full operation during any period of such interruption for at least seven days, as well as affording a regulation of peak loads on the power plant, this reservoir has exceptional value. It can be formed by a dam in a rocky canyon, 105 feet in height to the water line. As this reservoir is not

essential to the system of water supply until the power has been developed, its cost has not been included in the estimates.

SAN FERNANDO VALLEY RESERVOIRS.

The aqueduct delivers water into San Fernando Valley at an elevation of 1365 feet above sea level, or about 1100 feet above the main streets of Los Angeles. At a distance of three miles from the point of delivery a reservoir site has been selected, with a water surface elevation of 1133 feet, giving a further power drop of about 220 feet. This reservoir covers an area of 432.5 acres, and will have a storage capacity of 20,661 acre-feet, with a dam 130 feet in height.

The Board has visited the site of this dam, and is of the opinion that an earth dam can be constructed at a moderate cost, considering its great value and strategic position.

A second reservoir site has also been surveyed in the valley with a capacity of 45,762 acre-feet, requiring a dam but 40 feet in height—although having a top length of 9200 feet.

These reservoirs, when built by the Water Department, will serve not only as regulators of the supply for irrigation, to be drawn upon chiefly in the irrigation season of five months, but will maintain a constant water supply for the City of Los Angeles, even if the flow through the aqueduct should be interrupted for a considerable period. The capacity of the smaller reservoir alone would be more than six months' supply for the city at the present rate of consumption. Water can be piped from them to the natural gravel bed filters above the heads of the present aqueducts, and there purified by slow filtration through the gravel and sand which now serves the same purpose.

ESTIMATES OF COST.

The estimates of cost of the Los Angeles Aqueduct have been made up of the following general subdivisions, whose leading characteristics have already been described:

First Division.

Headworks on Owens River to Haiwee upper dam, consisting of 117,200 feet of unlined canal, from 700 to 800 second feet capacity, and 198,500 feet of masonry lined canal, of 800 to 900 second feet capacity. Total length, 313,900 feet (59.40 miles). Estimated cost ..... $ 3,712,100.

Average cost per foot, $11.85.

Second Division.

Haiwee Reservoir, with capacity of 63,780 acre-feet, to elevation 3760. Estimated cost of dams and accessories, diversion of highway around the reservoir, but not including land damages is.... 316,800.

Average cost per acre-foot of capacity, $4.97.

Third Division.

Haiwee Reservoir to Little Lake, a total distance of 81,700 feet (15.5 miles) through Rose Valley, with a gradient exceeding one per

cent for the first three miles, and two feet per thousand for the remainder. This is the first and easiest division of the aqueduct proper, designed to carry 410 second feet with ample factor for safety, lined throughout and covered where drainage of the country required to be passed over it. Estimated cost.....$ 481,800.

Average cost per lineal foot, $5.90.

Fourth Division.

From Little Lake to the south end of the siphon crossing of Indian Wells Canyon, a total distance of 127,935 feet, or 24.24 miles, involves the construction of 27,220 feet of tunnels, 85,000 feet of conduit lined with masonry and covered throughout, and 15,715 feet of siphon pipes. The total estimated cost of this division is ..... 3,088,400.

Average cost per foot, $24.14.

Fifth Division.

Valley section, Indian Wells to Red Rock Summit, a total distance of 106,000 feet, or 20 miles, consisting of 102,250 feet of conduit through Indian Wells Valley, with 3000 of deep cut on Red Rock Summit some 20 feet deeper than the normal; 1050 feet of steel flumes, and 2700 feet of siphon pipes, one of which is across the wash leading from Walker's Pass. The total estimate of this easy division is ..... 914,600.

Average cost per foot, $8.63.

Sixth Division.

This is a difficult section of 98,600 feet (18.66 miles) from Red Rock Summit to the Antelope Valley below Pine Canyon, requiring 39,272 feet of conduit, lined with concrete, 6000 feet of flume, 41,700 feet of tunnels, and 11,628 feet of siphon pipes, including the crossing of Jawbone Canyon. The total estimated cost of this section is ..... 2,760,900.

Average cost per foot, $28.00.

Seventh Division.

Antelope Valley from Pine Canyon to the west end of the valley, and to the portal of the long tunnel under Elizabeth Lake. Total length of line is 359,200 feet, or 67.81 miles. This division includes 3970 feet of siphon pipe, 1270 feet steel flume, 475 feet of tunnel, and 353,485 feet of conduit lined with concrete. The total estimated cost is ..... 3,076,000.

Average cost per foot, $8.56.

Eighth Division.

Elizabeth Lake Tunnel, 25,000 feet in length, from portal to portal (4.74 miles). Total estimated cost..... 1,913,200.

Average cost per foot of tunnel, $75.33.

Ninth Division.

From the diversion dam in San Francisquito Canyon to the point of delivery in San Fernando Valley is a total distance of 80,150 feet, or 15.18 miles, embracing 55,270 feet of tunnel in earth or sandstone, 9440 feet of conduit, 2240 feet of flume, and 13,200 feet of siphons. Total estimated cost ..... $ 1,957,500.

Average cost per lineal foot, $24.45.

The total of these subdivisions is a distance of 1,192,525 feet of constructed line, aside from the Haiwee Reservoir length and the natural channel of San Francisquito Canyon, or 225.87 miles, which is estimated in total at ..... $18,221,300.

To this total we add the following:

For construction railway, telegraph and telephone line, less a reasonable salable value on completion of the aqueduct, based on the scrap value of materials, estimated at $350,000	$ 1,150,000.
For cement mill, Mr. E. Duryee's estimate	300,000.
For temporary water supply development for construction purposes and its maintenance during the period of construction	300,000.
For fencing aqueduct where left uncovered for first few years and for permanent residences of caretakers	125,000.
For engineering and contingencies, 15%	3,014,400.
Total	$23,110,700.
For land and water rights, and for all legal and other expenses connected with their acquisition, from estimates presented by Messrs. Mulholland and Mathews, including what has already been expended, we add	1,375,000.
Grand total	$24,485,700.

The foregoing estimate of probable cost is made according to our best judgment, using the results of our personal experience, and all the data we have been able to collect of the cost of large works of similar character, but it should be clearly understood that the modifications of the line and grade of the aqueduct proposed by the Board have in some cases carried the new locations beyond the limits of the definitely mapped topography on either side of the located line. In the most difficult sections, however, our revised location has been instrumentally re-examined in detail, and checked. In less important places, where it was manifest that there were no material changes of material within a short distance of the original location, the estimates have been made on the original line, generally parallel with and not far distant from the new line.

In forming our judgment of the cost of excavation, we have been guided in part by our own observations, and in part by the notes of the classification of materials made on the ground by the field engineers. We have assumed that the cement will be manufactured at a cement mill, to be erected by the city on property already acquired, and that the cost of the cement at the mill will be one dollar per barrel, which is substantially the cost as determined by Mr. Edward Duryee, the cement expert in the employ of the city.

The figures are based upon the assumption that the work will be done on a business basis, unaffected by politics, and with able and honest men in charge of all departments of the work. They are intended to include all money already expended, to safely cover the contingencies and delays ordinarily met with in this class of work, and include an allowance for the extra cost of the work on the eight-hour basis as compared with the ten-hour basis, on which most of the large engineering works have been constructed, whose cost data are available.

TIME REQUIRED TO COMPLETE THE PROJECT AS OUTLINED.

In our opinion five years is the minimum time in which the projected works can be completed so that water from the Owens River can be delivered into the San Fernando Valley.

The controlling feature in determining the time is the Elizabeth Lake tunnel, the longest on the line, which will be about 25,000 feet in length, exclusive of the deep approaches at its two ends, and which must be driven from only four headings, two of which will start from a shaft about 350 feet in depth located in the valley near Elizabeth Lake. It will take the larger part of a year before work can be actively begun on tunnel proper, and about four years more for the excavation of the tunnel and lining it throughout with concrete masonry.

Five years also appears as little time as may be prudently reckoned for the completion of the long series of shorter tunnels in the rugged country between Little Lake and the north end of the Antelope Valley section of the conduit.

Due consideration of economy dictates that work should not be begun on these northerly tunnels until the railroad pertaining to the aqueduct has been extended far enough north to give convenient access to them, and until suitable power plants have been provided, operated either by steam power, or by water power from Cottonwood Creek transmitted electrically, as may be found most convenient and economical.

While these northerly tunnels are all of them short in comparison with the Elizabeth Lake tunnel and any one could be constructed much more quickly, there will be economy in avoiding unnecessary duplication of plant for carrying them all on simultaneously, and five years from the present time appears little enough to allow for completing them all.

The present condition of the labor market and the fact that less work can be accomplished in an eight-hour day than on a ten-hour day must also be taken into consideration in considering those portions of the work outside of the tunneling.

On certain of the transcontinental railroad extensions now being made to the Pacific Coast, it is reported that much less rapid progress than desired is being accomplished because of the scarcity of labor.

WATER POWER.

There are three localities along the line of the aqueduct where a surplus fall exists that will permit the development of power from water flowing on its course from Owens Valley to the San Fernando Valley. The most important of these localities is in the San Francisquito Canyon, about 45 miles northerly from the City of Los Angeles and a short distance down stream from the outlet

of the Elizabeth Lake tunnel. A total drop of nearly 1500 feet is available in the San Francisquito Canyon, and from present indications it appears most advantageous to divide this fall between two power drops, of which the upper one, and the first to be developed, would have about 1060 feet, and the lower about 415 feet of net available fall on the water wheels.

The third site for power development is found a short distance below the end of the aqueduct in the San Fernando Valley, and near the upper of the two proposed San Fernando Reservoirs. The net fall available at this point would be about 215 feet.

The fourth power site is found near Little Lake, a distance of nearly 150 miles northerly from Los Angeles, and about 15 miles down stream from the proposed Haiwee Reservoir. The net fall available at this point, after relocating the line of the aqueduct between Little Lake and Haiwee, would be about 270 feet.

With an average delivery of 400 cubic feet of water per second, there could be developed at these several points, and transmitted to the City of Los Angeles, after making due allowance for the losses in generation and transmission of electrical power, the following amounts, measured in 24-hour electrical horse power at the point of delivery:

From Upper San Francisquito site	.....	25,000	H. P.
" Lower " "	"	11,000	"
" Fernando	"	6,000	"
" Little Lake	"	7,000	"
Total	.....	49,000	"

The above would be available 24 hours per day, and seven days in the week.

Fortunately a reservoir site has been found near Fairmont, at the head of the Elizabeth Lake Tunnel, which will permit developing and transmitting a much larger amount of power during working hours, and moreover this Fairmont Reservoir can be made of sufficient capacity so that it could supply a full daily amount of power for a period of about eight days, while the aqueduct between Fairmont and the Haiwee Reservoir was shut off for inspection, cleaning or repairs.

It is also possible, by means of small and inexpensive dams, to provide small equalizing reservoirs immediately down stream from each of these two power houses in the San Francisquito, such that the water for power can be drawn at a rate of flow varying throughout the 24 hours, and that storage can be accumulated over Sunday, while the aqueduct delivers continually at the normal rate of 400 cubic feet per second.

Considering that an ordinary factory working nine hours per day or 54 hours per week, out of the 168 hours, and thus having a "load factor" of 32% could be supplied with 300 H. P. during working hours from the same volume of water that is required for developing 100 H. P. continually 24 hours per day, and seven days per week, the great value of equalizing reservoirs and conduits suitable for a higher rate of delivery during the hours of greatest demand becomes apparent. The load factor for future conditions and after the building of more factories may be different from that for present conditions of railway and lighting use.

The Board has for this reason planned Elizabeth Lake Tunnel and estimated its cost with diameter and gradient such as to permit drawing the water from the Fairmont Reservoir at two and a half times the average rate, or at the rate of 1000 cubic feet per second during those hours in which the demand for power is greatest.

Under this arrangement, it will be feasible to install electrical machinery, and supply power during the hours of maximum use, up to the amount of about 60,000 H. P. at the Upper San Francisquito Power House, and about 20,000 H. P. at the Lower San Francisquito Power House.

So far as is shown by the surveys thus far made, it will not be expedient to provide for a large peak load increase at the Fernando Power House, or the more remote power site at Little Lake.

We, therefore, have as the total power that may be developed under the 40% load factor for the two San Francisquito sites, a total of 80,000 H. P., and adding to this the 13,000 H. P. that may be developed at San Fernando and at Little Lake gives a total of 93,000 H. P. measured at the point of delivery in hours of greatest demand, which may be developed from the Owens River water along the course of the proposed aqueduct.

The conditions for the economical development and maintenance of the power are very favorable and its safety against interruption or diminution by drouth, and the permanent character of the aqueduct, tend to make the power development feature particularly attractive and valuable.

ENGINEERING ORGANIZATION.

We have already indicated the importance of making further surveys and studies to ascertain the best and most economical locations for the aqueduct.

The work of building a water-tight and durable aqueduct, erecting safe and stable dams, and of constructing the great steel siphon pipes which will be required is of a far more exacting character than a railroad construction.

The Los Angeles Aqueduct is a work of such magnitude and extends over so many miles of territory somewhat remote from the base of supplies, that it will be a physical impossibility for the chief engineer and the principal assistant Engineer to be upon all parts of the work frequently enough to give the quick decision that is necessary for overcoming obstacles. It will, therefore, be essential to have in the field engineers of proved executive skill and resourcefulness, who are expert in the line of work which they are to supervise. We recommend substantially the plan of organization which has been successfully adopted upon the Metropolitan Water Works of Massachusetts and upon the New York Aqueduct which is now being prepared for construction. On the Metropolitan Water Works, representing about the same cost as the Los Angeles Aqueduct but covering an extent of not more than sixty miles, and where all parts of the line were easily accessible, five of these skilled engineers, known as department engineers, were employed, and all of them were men who had had sufficient experience to enable them to fill a position as chief engineer upon an important work.

In New York, although the work has not yet advanced beyond the preliminary stage, five department engineers of this high grade are now employed. Consulting engineers were also connected with both of these works continuously.

Our recommendation is, therefore, that under the chief engineer and the

principal assistant or deputy chief engineer the work be divided into several main departments, each placed in charge of a department engineer having his principal office near the work which he is to supervise.

In order to secure suitable men for these positions, it will be true economy to pay liberal salaries sufficient to attract men from other work in these times when the abler engineers are all busy, rather than to take men of less ability and unproved executive skill.

There should be an efficient staff at headquarters to prepare designs for the work of construction and to make the necessary studies and investigations.

The above recommendations are founded upon the experience on similar large aqueducts where most of the work has been done by contract. If this work is to be done in large part by day labor a somewhat different organization would be required, including men of special skill in several branches of the work.

CONCLUSIONS.

Our conclusions may be briefly summarized as follows:

1. We find the project in every respect feasible, and that it involves no great difficulties of engineering or construction other than those arising from mere length and distance.

2. That a supply of about 400 cubic feet of water per second of good quality for domestic use can be brought to the City of Los Angeles or its vicinity from the Owens River and its tributaries.

3. That the cost of all water rights, lands and structures required for the collection, storage and delivery of this water at the head of the San Fernando Valley, but not including the cost of the future Long Valley reservoir, or those in the San Fernando Valley, or structures required solely for the development of power, will be about twenty-four and one-half million dollars.

4. That from the water conveyed by this aqueduct, power can be developed and transmitted electrically to the city of Los Angeles and vicinity, sufficient to supply 49,000 horse power continuously, 24 hours per day, and every day in the year, or a correspondingly larger amount if portions of it are used only during ordinary working hours.

In brief: We find the project admirable in conception and outline, and full of promise for the continued prosperity of the City of Los Angeles.

Respectfully submitted,

(Signed.) JOHN R. FREEMAN,
(Signed.) FREDERIC P. STEARNS,
(Signed.) JAMES D. SCHUYLER,
Board of Consulting Engineers.

APPENDIX F.

LIST OF LANDS PURCHASED FOR THE LOS ANGELES AQUEDUCT.

From Whom Purchased.	No. of Acres.
Fred Eaton (Rickey L. & C. Co)	22,670
J. J. and Catherine Stewart	80
Mark P. Hand	160
John R. Turner	1,800
Maggie J. Skinner	160
E. H. Edwards and Estate of B. J. Stevens	1,400
Irv. H. Mulholland	440
A. W. Eibeshutz	160
H. C. Hamilton	160
M. Q. Watterson	200
S. C. F. Wrinkle	1,800
Stoddard Jess	680
H. L. Minkler	320
Henry Arna	40
John H. Lubkin	240
Jesus J. Carrasco	160
Estate of Treglown	240
Silas H. Reynolds	160
Margaret James	640
Harry M. Gorham	640
Silas H. Reynolds	160
Chas. B. Benjamin	15
Benjamin J. White	40
Lars Erik Aronson	60
J. A. Sandy	40
Edward De Mots	160
Max M. and Harriet T. Skinner	200
Flora I. Seifried	40
J. V. Skinner	200
C. A. Skinner	220
P. W. Forbes	160
Omie I. Mairs	1,880
W. H. Baird	400
A. G. Goodale	160
Thos. Mills, Alena Mills and John McCord	160

Finlay and Jessie F. McIver	400
Ellen Nora J. Baxter	160
F. E. Russell	1,600
Carrie Hunter	160
Irv. H. Mulholland	640
Fred F. Wheeler	600
Will M. Noble	40
Mark P. Hand	320
G. W. E. Griffith	320
F. M. and E. A. Crocker	320
Wm. H. Mitchell	560
Annie Reynolds	40
L. A. Norviel	320
Augusta M. L. Lubken	160
The Alvord Company	390
James Jones	600
Chas. A. Collins	4,720
Estate of Thos. C. Boland	1,280
Emmett Rixford	480
F. E. Densmore	360
Clarence Johnson	40
Ed Walker	160
Wm. Penn. Col. Assn. of Cal.	12,150
Mira E. Orr	480
R. A. Lowe	1,008
Frankie G. O'Neal	80
Pauline Aguirre	40
Estate of C. B. White	1,440
Maurius Jullien	120
Manuel Silva	480
Estate of Kline	640
Jesus J. Carrasco and E. H. Edwards	685
W. A. and H. M. Hammett	320
H. D. Gill	160
W. A. Williams	40
Fruit World Publishing Co.	57
Ben H. Yandell	440
James Hillyer	7.34
Thos. Mills and Alena Mills	21
Amos Davis	6.50
F. W. Henley	15
Fred Eaton	362
Fred Eaton (Rickey Ranch—Long Valley)	2,684
Katherine Wolff (Swartout Reservoir)	320
Peck (Swartout Reservoir)	160
Jacob Ablutz (Swartout Reservoir)	1,080
Parker	160
E. W. Reid (Swartout Reservoir)	320
Cuddeback, Blackley & Rose (Tehachapi Cement Lands)	3,000
Jno. P. Cuddeback (Tehachapi Cement Lands)	160

Mehan and Mathews (Tehachapi Cement Lands)	120
Edward Hamilton (Tehachapi Cement Lands)	102
Morgan Price (Fairmont Reservoir)	10
C. R. Rinaldi (Fernando Reservoir)	171
Catalina Lopez (Fernando Reservoir)	27
Total	76,581.84

	No. of Acres.
Owens Valley and Long Valley Lands	70,951.84
Swartout Reservoir	2,040.00
Tehachapi Cement Lands	3,382.00
Fairmont Reservoir	10.00
Fernando Reservoir	198.00
	76,581.84

(For location of property see General Land Map.)

APPENDIX G.

CITY ATTORNEY'S OPINION DEFINING THE POWERS OF THE BOARD OF PUBLIC WORKS.

W. C. Mushet, Esq., City Auditor, Los Angeles, Cal.:

Dear Sir: I am in receipt of your letter of February 25, 1907, in which you ask me the following questions:

> First: "Is the Owens River enterprise a 'municipal affair'?" and
>
> Second: "Who controls the expenditure of bond money voted or to be voted for the Owens River enterprise—the Council, Board of Public Works or the Board of Water Commissioners?"

In answer to your inquiries, I beg to say:

(1) Municipal bonds for public improvements are authorized by an Act of the Legislature, approved February 25, 1901, which provides in general terms for the incurring of indebtedness by cities for municipal improvements; that is, for their "acquisition, construction and completion." There are no provisions in the City Charter providing the procedure for the issue of improvement bonds, and therefore our first inquiry must be to said Act. The general scheme for issuing bonds is, that the City Council, in the first instance, determines what municipal improvement is necessary to be "acquired, constructed or completed," and thereupon calls an election and submits the question of the issue of the bonds therefor to the voters. If the bonds are voted favorably, they may be issued and sold by the City Council at such time, in such manner, and in such amounts as the City Council shall deterimne.

In cities which have no Board of Public Works, the control of the Council goes further, and includes the letting of contracts for the public improvements for which the bonds were voted and issued; the employment of agents, superintendents and engineers, for such improvement, and generally, to the use of all lawful ways to protect the rights and interests of the municipality therein. But in cities operating under freeholders' charters, as is the case in Los Angeles, the direct power and control of the City Council over bond moneys ceases with the sale of the bonds and the placing of the proceeds thereof in the municipal treasury to the credit of the proper improvement fund.

Sections 8 and 9 of the Act in question each contain the following proviso:

> "Provided, however, that in cities, towns or municipalities operating under a charter, heretofore or hereafter framed under Section 8 of Article Eleven of the Constitution, and

having a Board of Public Works, all the matters and things required in this Section to be done and performed by the legislative branch of the municipality shall be done and performed by the Board of Public Works of such city, town or municipality."

The matters and things referred to in said Sections, which would be done by the City Council, were it not for the existence of the Board of Public Works, are: To make rules and regulations for carrying out and maintaining the proposed improvements; the appointment of the necessary agents, superintendents and engineers to look after the same, and the letting of contracts for the construction or completion thereof. These matters, all of which relate to the expenditure of bond money, are, in the City of Los Angeles, devolved upon the Board of Public Works.

The Act of the Legislature referred to deals with public improvements **in the process of the making thereof**, and has nothing to do with, and makes no provision for, the management or control of the sale after completion, as distinguished from the **acquisition, construction or completion** of the same. Bonds are not issued under that Act to maintain, operate or conduct public improvements, but they are issued for, and the proceeds thereof are to be devoted exclusively to, the work of acquiring, constructing and completing the specified public improvement proposed. It is important to bear in mind this distinction, because it has a vital bearing upon the powers and duties of the Board of Public Works in relation to public improvements for which bonds have been issued.

(2) It is necessary then, in the next place, to examine the City Charter in order to determine the power of the Board of Public Works over the construction of public improvements authorized by the City Council, and to pay for which bonds have been issued and sold. And in this connection, I will refer, first, to the Board of Water Commissioners, and will confine the inquiry to Water Works, as that is the particular subject of your communication.

By Section 192 of the Charter, "the Water Department," which is under the management and control of the Board of Water Commissioners, is expressly created for the purpose of managing and controlling all waters and water rights that are now or may hereafter be owned by the City of Los Angeles. It will be observed that in thus defining the function of the Water Department the Charter contemplates that its jurisdiction is to **manage and control** waters and water rights.

Further, in specifying the powers of the Board of Water Commissioners, the Charter further provides (Subdivision G, Section 192) that said Board has power

"to manage and control all waters, water rights and water bearing lands, and all water works, reservoirs, zanjas and ditches belonging to the city," also

"to construct, operate, maintain and extend water works, dams, reservoirs, zanjas, ditches, canals and other means of supplying the city and its inhabitants with water, and to acquire and take, by purchase, condemnation or otherwise; and in its own name to hold, as special trustees for the city, any and all property, including waters and water rights, situated within or without the limits of the city, other than the waters of the River of Los Angeles, that may be necessary or convenient for such construction, operation, maintenance or extension."

The Board of Water Commissioners has undoubtedly the power to construct and extend water works; but, as I will explain, that power is limited to the construction thereof out of certain specified moneys, and **does not extend to the construction thereof out of bond moneys.**

The power of the Water Commissioners to control and order the expenditure of money is restricted to the expenditure of moneys received from the sale or use of water. Such moneys shall be deposited in the treasury of the city and form what is known as "The Water Revenue Fund." This fund cannot be used for any other than the following purposes:

> "First: For the necessary expenses of conducting the water department, of operating the water works, and of making all current and ordinary extensions, betterments and repairs;"
>
> "Second: For extraordinary improvements of and betterments to the property, works and systems of supply and distribution of the water department, including the purchase of necessary lands, water rights and other property."
>
> "Third: The payment * * * of installments of interest or principal or of interest and principal coming due upon outstanding water works bonds."
>
> "Provided, however, that the said Board may, in its discretion, so fix the water rates as to produce a revenue **sufficient only** for the purpose of defraying the necessary expenses of conducting the water department, of operating the water works, and of making all current and ordinary extensions, betterments and repairs, **and for no other purpose.**"

It is manifest from these provisions of the Charter that the jurisdiction of the Board of Water Commissioners, as the body having charge or control of the water department, is to manage and control an existing public improvement; that is, a water system in being, which is maintained by a Water Revenue Fund made up of water rates. The Board of Water Commissioners does of course, in the maintenance of such a system, have to deal to a certain extent with matters of construction, betterment and improvements, and even with the acquisition of lands; but it can construct improvements and otherwise deal with water works and systems of supply only out of the proceeds of water rates which go to make up the Water Revenue Fund.

(3) The Owens River enterprise, which is in short a system of water supply, is a public improvement for which the city is authorized to incur indebtedness under the Bond Act of 1901, above referred to. If bonds for that purpose are authorized and sold, the expenditure of the proceeds thereof must be devoted exclusively to that purpose, and will be under the control of the Board of Public Works, and not of the City Council, or of the Board of Water Commissioners.

That Act provides, as has already been said, that where a city operating under a freeholders' charter, has a Board of Public Works, such Board shall let all contracts and do all other things needful to acquire, construct or complete the public improvement contemplated.

The City Charter, as amended at the last municipal election (the last amendments to which became effective by approval by the Legislature on February 7 of this year), is in complete harmony with those provisions of the Bond Act which places the disposition of the bond moneys in the hands of the Board of Public Works.

Section 146 of the Charter defines the powers of the Board of Public Works, and it provides:

> "The Board of Public Works shall have charge, superintendence and control, under such ordinances as may from time to time be adopted by the City Council * * *
>
> "(4) Of the design, construction, alteration, repair, maintenance and care of all public works and improvements, and of all public buildings belonging to the city; * * *"
>
> "(6) Of all public utilities that are now or may hereafter be owned, controlled or operated by the city, other than water works."

Subdivision 6 of said Section 146, just quoted, does not refer at all to the acquisition, construction or completion of any public improvement; and so far as it relates to water works, it can only mean that the charge, superintendence and control thereof, as an existing public utility, "owned, controlled or operated by the city," is not under the charge, superintendence or control of the Board of Public Works. This provision deals with public utilities already acquired, with works that have already been completed, and it cannot be inferred from that because the Board of Public Works does not have charge, superintendence and control of water works that are "owned, controlled or operated by the city," that therefore it does not have jurisdiction over the **construction** of such works. The acquisition or construction of a public improvement, and the operation thereof after such acquisition or construction, are two separate and distinct things, and are recognized as distinct in the Charter; in the case of water works, the Board of Water Commissioners **operates** them, and the Board of Public Works, so far as bond moneys are applied thereto, **constructs** them.

As the Board of Public Works, that part of Subdivision 4 of Section 146, above quoted, which would relate to water works would in my opinion, confine the Board to their design and construction, in as much as by other provisions of the Charter, the repair, maintenance and care of "water works" as a system or plant in operation, are devolved upon the Board of Water Commissioners.

(4) I now come to a consideration of the amendments to the Charter, approved by the Legislature February 7, 1907, relative to the Board of Public Works. An inspection of them will show conclusively, in my opinion, that the Board of Public Works has control over bond moneys issued for public improvements, and used in the acquisition, construction or completion thereof; and that in the case of water works, or to be specific, of the Owens River enterprise, the Board of Public Works has such power and control, as against both the City Council and the Board of Water Commissioners.

By the amendments to the Charter, the Board of Public Works has power to acquire by purchase or otherwise all property necessary for any public work or improvement which is to be paid from the proceeds of bonds; all contracts for the construction or completion of any work or improvement of which the Board has charge are let and entered into on behalf of the city by the Board of Public Works. Said Board presents each year, in December, to the City Council a report showing the amount of money received from the sale of bonds, and the manner of the expenditure thereof, and the balance on hand in each bond fund; also a monthly statement of expenditures of moneys derived from the sale of bonds. When the construction or completion of any public work or improvement is to be paid out of the proceeds of the sale of bonds, and

is carried on outside of the city (as is the case with the Owens River enterprise), the Board may appoint a Disbursing Agent, whose duty it shall be to disburse moneys therefor in the manner specified in Section 151 of the Charter. All demands payable out of funds derived from the sale of bonds, are presented to the Board of Public Works and approved by it before presentation to the City Auditor. If he shall reject a demand, he returns the same to the Board of Public Works, and not to the City Council. The demand returned to the Board, with the Auditor's objections, shall be again considered by the Board, and if such demand be approved, the objections of the Auditor are thereby overruled. And if so overruled, the demand is delivered to the City Auditor, who must then record the same, as in the case of demands approved by him.

All these provisions point directly to the conclusion that the Board of Public Works has jurisdiction over the construction and completion of the Owens River enterprise, which of course carries with it the expenditure of moneys therefor, and that neither the City Council nor the Board of Water Commissioners has control thereof. When the Owens River enterprise is completed, if the Charter then stands as it does now, the acqueduct, with its appurtenances, and the water supply thereby obtained, will be turned over to the Board of Water Commissioners, and they will manage and control it.

(5) As to the acquisition of lands by the Board of Public Works in the furtherance of the Owens River project, I am of the opinion that the Board of Public Works has full power to acquire such lands itself for the city, as is expressly specified in Section 146½ of the Charter. The provisions of the Charter relative to the making of contracts by the Board of Public Works for the performance or furnishing of "labor, materials or supplies required for the construction or completion" of the Owens River project do not relate to the acquisition of lands.

The acquisition of lands does not fall within the classification of "labor, materials or supplies;" and the Board of Public Works has express authority to purchase them at its own instance for the Owens River project. In order to purchase lands, if a resolution or order be adopted by the Board, providing for the drawing of the demand for the purchase of the parcel of land necessary for that enterprise, or as a payment of money on a contract for the purchase thereof, and a demand in pursuance of such resolution or order is presented to you, duly signed, that is all that is necessary to make the demand complete. You have the power to audit such demand, and reject it should you deem such rejection necessary on any ground affecting its regularity; but if upon the return of such demand to the Board of Public Works, your objections are overruled, the demand must be registered, as in other cases, and the usual procedure thereon follows, as in other cases.

In conclusion, I therefore answer your inquiries as follows:

The Owens River project is a municipal affair; and while the method of voting bonds therefor is provided by general law, and not by charter, the manner and method of letting contracts for that project, and in short all things relating to the acquisition, construction and completion of said enterprise are regulated by the Charter, and are under the control of the Board of Public Works.

Respectfully yours,

(Signed.) LESLIE R. HEWITT,
City Attorney.

Dated March 1, 1907.

APPENDIX H.

REPORT ON PROPOSED LOS ANGELES AQUEDUCT RAILWAY

(A CONSTRUCTION RAILROAD.)

By W. S. Post.

REQUIREMENTS AND CONDITIONS.

The following uses will be subserved by an Aqueduct Railway:

(a) Through haulage of material (an average distance from Mojave of 40 miles): Cement, steel for reinforcing, bridges and pipe, steam shovels, machinery, supplies, coal, etc., powder, contractors' commissary stores, contractors' feed and passengers.

Local haulage of gravel, boulders and crushed rock, average of (say) one mile, and movement of material from storage and redistribution of excess.

Haul is estimated for five years of construction as follows. See Table "A":

Through tonnage	287,300
Through ton miles	12,435,800
Through train miles	497,000
Through train miles per day	331
Local tonnage	1,555,400
Local ton miles	1,573,000
"Work" train miles	62,920
"Work" train miles per day	42
Passengers, per day	40

(b) The railway to be used exclusively for the conduit, to last five years and assumed to have no extra value for public business.

(c) Use of track, if feasible, after completion of conduit, as an inspection and maintenance railway.

(d) Railway transportation is expected to cover the sections of conduit.

1. From Mojave to Olanche, 92 miles.
2. From Mojave to Neenach, 35 miles.

(e) It is doubted whether the additional 25 miles, Olanche to Mt. Whitney, S. P. Ry. Junction, would be justified, but may be considered on account of hay supply, say 60,000 tons.

(f) It is noted that Mojave-S. P. Ry. and Santa Fe Ry. Junction is broad-gaged, and S. P. at Mt. Whitney Station is narrow-gage.

BROAD OR NARROW GAGE.

A choice must be made at the outset of gage—standard or three-foot gage.

In Favor of Broad Gage.

(a) Standard engines and cars—facility of purchases and renewal repairs.

(b) No need of freight transfer amounting to 160,000 tons which at $.50 = $80,000.

(c) Utilization of standard steam shovels.

In Favor of Narrow Gage.

(d) Saving 25% in length of ties.

(e) 20% in grading.

(f) Shorter engine wheel base, allowing higher curvature and, as a rule, permitting use of conduit curves.

(g) Greater facility in laying spur tracks.

(h) Direct connection with narrow gage tunnel tracks.

Neutral.

(j) Curve resistance is slightly in favor of narrow gage, but may be compensated in the gradient. Weight of rails, rolling stock, trestles and maintenance are about the same.

COSTS.

An estimate has been prepared for a line from Neenach through Mojave to Owens Lake, 127 miles, for a broad-gage roadbed, using the following assumptions:

Maximum grade, 4%—65-ton engines. Roadbed in cuts 16 feet. Roadbed in fills 12 feet. See Tables "B" and "C."

Average cost (ready for traffic), $8255 per mile—or a total cost for 127 miles, $1,050,000.

Maximum cost per mile in Red Rock Canyon is $13,352 and minimum (light plains) is $6935.

The equipment cost (second-hand rolling stock), see Table "D," is estimated to be $68,900.

The total cost of operation, five years, added to fixed charges and the net cost of the whole railway, is as follows: (See Table "E.")

1.	Operating expense, five years.....	$ 414,000
2.	Fixed charges, interest on cost and equipment at 4%.....	223,780
3.	Net cost—when abandoned.....	768,500
		$1,406,280

This sum represents the amount which the railway must earn in five years to pay for itself and carry the specified tonnage.

The total train miles being 559,920, the cost per train mile is

$$\frac{\$1,406,280}{559,920} = \$2.51$$

and the cost per ton-mile is

$$\frac{\$1,406,280}{14,007,700} = \$0.10$$

This is evidently a severe condition to place upon the railway—to pay for itself and be abandoned in five years. If only items (1) and (2) of operating cost be considered

The cost per train-mile becomes..... ...$1.14
The cost per ton-mile becomes..... .0455

Operating Cost of Narrow-Gage.

On the same conditions, a narrow-gage, allowing 20% reduction in roadbed and 25% in ties, we would have a construction cost of $7562 per mile, or $960,000, and the same operation cost five years including fixed charges and net cost, plus $80,000 for transfer freight=.....$1,379,280

Cost per train-mile =..... $2.46
Cost per ton-mile =..... $0.099

Corresponding Wagon Haul.

Statistics of wagon transportation vary from 35 cents per ton-mile to 15 cents (a special case in the Mojave Desert). Assuming a rate of 25 cents per ton-mile, we have:

Cost of wagon transportation 14,008,800 ton-miles at 25 cents.....$3,502,200
Cost of railway transportation..... 1,406,280

Saving in favor of railway.....$2,095,920

The above rates show that it is economical to extend the railway line within 12 miles of the end of the conduit, hauling material in wagons for remainder of distance.

CONCLUSIONS.

(a) The high cost per ton-mile is due to the condition imposed that the railway shall pay for itself as a construction road. The public business which would arise with Owens Valley, mines and salt works, if carried on the line, would obviate the need of charging cost of construction to operation. Such a road should be self-supporting, and would probably show a cost of 2 cents per ton-mile.

The solution is a legal one, either by making a contract with a railway company to carry the city's material, or with an operating company to operate over the city's line and purchase the road at the expiration of five years.

(b) The grade should be reduced to 2% ruling providing for a pusher grade of 3½% at Red Rock Canyon and Little Lake Summit. The through trainload will be doubled by this means, the operating expense reduced 40%, and the cost per ton-mile to 7 cents.

(c) The use of say 10-ton engines for "work" train purposes, reducing the time of standing idle and serving a larger number of sections. The cost should then be about 8 cents per ton-mile, or about 16 cents a yard for transport of gravel and rock one mile. If electric power is provided for other purposes, an economy will probably be found in electric 10-ton locomotives costing $2400 each, delivered.

(d) If the track is placed along or on the conduit as an inspection track, the gage should be narrow-gage throughout.

TABLE "A."

HAULAGE IN DETAIL.

The total tonnage in five years' construction is estimated as follows:

(a) THROUGH HAUL.

	Tons.	Ton-Miles.
1. Cement—Mojave to Little Lake, full conduit section, 0.2 tons per lin. ft. × 5280 × 80 miles; average haul 40 miles	84,480	3,379,000
2. Cement—Little Lake to Lone Pine, reduced or cheapened section, say .12 ton per lin. ft. × 5280 × 60; average haul 92 miles	38,020	3,498,000
3. Cement—Mojave to Neenach, 0.2 ton per lin. ft. × 5280 × 35; 17 miles haul	37,000	628,000
4. Cement—Add beyond Neenach, same; 25 miles haul	26,400	660,000
5. Steel—Reinforcing—covered section, 100,000 ft. at 40 lbs. per ft.; average haul 60 miles	2,000	120,000
6. Steel—Syphons, 553 lbs. per lin. ft. × 30,000 ft.; average haul 50 miles	8,300	415,000
7. Steel—Flumes, 8320 ft. at 660 lbs.; average haul 35 miles	2,750	96,250
8. Machinery—Average haul 50 miles	1,000	50,000
9. Steam Shovel—Coal for—700,000 yds. exc.; 50 miles haul	2,500	125,000
10. Powder—20 miles haul	700	14,000
11. Contractors' Commissary—Supplies, 1000 men 5 yrs.; 40 miles haul	3,000	120,000
12. Contractors' Feed—60 lbs. per animal per day, 1000 head, 5 yrs.; 40 miles haul	55,000	2,200,000

(b) LOCAL HAULAGE.

11. Gravel, Boulders and Crushed Rock—1½ yds. per ft., 127 miles (¾ total handled by car, average haul 1 mile)	1,404,000	1,404,000
12. 5% Redistribution—Cement, steel, etc.; 2½ miles average haul	10,000	25,000
	1;675,150	12,734,250
Add 10%	167,550	1,273,450
Total tonnage	1,842,700	14,007,700
		Passenger Miles.
13. Passengers—20% of working force changed each month, say 20 per day + 20 pay. inspection, etc. = 40 per day; average 30 miles		2,160,000

A.

SUMMARY. FREIGHT.

Through tonnage (10% added)	287,300
Through ton-miles	12,435,800
Using ½ trainload for effective live load, 4% grades, 65-ton engines = 50 tons per train and doubling train mileage for empties return.	
Total through train-miles	497,000
Total through train-miles per day (300 days per year)	331
Requires two trains round trip per day, 170 miles per day—1 engine, 3 cars, 1 caboose.	

LOCAL FREIGHT.

Local tonnage	1,555,400
Local ton-miles	1,573,000
Using trainload as above:	
"Work" train miles	62,920
Total "work" train miles per day	42
Say 2 "work" trains—1 engine and 8 flats each.	

TABLE "B." ESTIMATED COST—GRADING.

Miles.	Earth hauled @ $.16	Earth borrowed @ $.14	Loose rock @ $.40	Solid rock @ $.60	Box Culverts @ $80 per.	Trestles under 10 ft. @ $8.70 per lin ft.	Trestles over 10 ft. @$11.50 per lin. ft.	Tunnels. @ $40 per lin. ft.	Cost per mile of grading.	Total cost.
Mojave to Neenach, 35 miles.				Estimated.					$ 850	$ 30,000
1—10, Mojave to Pine	$2,880	$ 2,660	.....	.....	$2,400	$7,310	.....	.....	1,525	15,250
11—18, Pine to Jawbone	2,310	2,140	.....	.....	1,760	3,070	.....	.....	1,160	9,280
19—27, Red Rock Canyon	2,780	10,940	$7,840	$19,450	3,920	2,780	$4,960	$12,000	7,185	64,670
28—33	1,730	1,600	.....	.....	1,440	696	.....	.....	910	5.466
34—45	5,590	3,460	.....	.....	4,160	2,500	1,470	.....	1,430	17,180
46—56	6,530	3,390	200	.....	2,880	2,870	2,940	.....	1,700	18,810
57—67	6,240	3,180	760	3,870	3,520	973	552	.....	1,750	19,195
68—92				Estimated.					1,000	25,000
Total 127										$204,851

$$\frac{204,850}{127} = \$1615 \text{ per mile, average for total length, 127 miles.}$$

TABLE "C." TOTAL COST.

COST PER MILE.

Clearing right of way, $10 acre	$ 130
Average grading, per mile	1615
Ties, 2464 at $.60	1478
Rails, 50 lbs.—79 tons at $42	3320
Splice bars, 4,000 lbs.	
Spikes, 5,000 lbs.	
Track bolts, 1,400 lbs.	
10,400 lbs. at $.03	312
Track laying	360
Water stations $\frac{3600}{20}$	180
Sidings $\frac{8000}{20}$	400
Telegraph	300
Right of way (govt.)	40
Total cost per mile	$8255

Total cost 127 miles	$1,050,000
Salvage value per mile:	
Ties, 10% $ 148	
Rails, 80% 2212	
Buildings and trestles, 20%. 124	
$2486 × 127 =	316,000
Net total cost when abandoned	$ 734,000

TABLE "D."

EQUIPMENT. COST (All Second Hand).

5	engines, 65-ton,	at $5200	$26,000
2	passenger cars,	at 4000	8,000
1	baggage car,	at 3000	3,000
15	box cars,	at 500	7,500
2	cabooses,	at 800	1,600
32	flat cars,	at 400	12,800
	Miscellaneous		10,000
			$68,900

COST PER TON MILE.

5 years' operation ..... 127 miles

Operating Expense (Annual).

2 freight trains, 322 train miles per day at $.50 per train-mile, 365 days	$58,800
2 work trains per day at $40 per day, 300 days	24,000
	$82,800 × 5 yrs. = $414,000

Fixed Charges.

Interest on cost of construction, $1,050,000 at 4%, 5 yrs	$ 210,000
Total cost, less salvage	734,000
Interest on equipment, $68,900 at 4%, 5 yrs	13,780
Equipment, less sale value	34,500
Total cost of operation	$1,406,280

Five years, including all charges and cost of plant.

$$\text{Cost per ton-mile} = \frac{\$1,406,280}{14,007,700} = \$0.10 \text{ per ton-mile.}$$

APPENDIX I.

REPORT ON

PORTLAND CEMENT MATERIALS.

BY E. DURYEE.

Los Angeles, Cal., Sept. 29th, 1906.

Mr. Wm. Mulholland, Chief Engineer.

Sir: In compliance with your directions I have investigated the cement making materials found in the vicinity of Tehachapi.

The limestone deposits there are numerous, not far distant from the railroad, and some of them are adapted to economical quarrying operations.

The rock is sufficiently pure and uniform for cement making purposes. The deposit of clay examined is of good quality and of more than sufficient extent for the project contemplated.

The proximity of Tehachapi to the line of the proposed aqueduct, the short railroad hauls for Bakersfield fuel oil, and of the manufactured cement to the line of the aqueduct, the abundant supply of good water, a nearby town from which to secure labor and supplies, and the possession of a mill and townsite and clay deposit alongside the railroad, contribute to make this location an ideal one for the work contemplated.

THE PROPOSITION.

It is proposed to erect a modern Portland cement works of a daily capacity of 1000 barrels, on the Cuddeback ranch, five miles east of Tehachapi, on the S. P. Railroad, and adjoining the extensive clay beds recently secured with the Cuddeback ranch. Limestone will be transported from the quarry, on which the city holds an option, by a private electrically operated tram, a distance of two miles, to the cement works. The manufactured cement will be transported from the mill over the S. P. Railroad to the nearest point on the conduit line near Warren, a distance of about 10 miles.

The raw materials used for the trial mixtures were obtained by myself during personal visits to the deposits, and were taken with the view of securing representative samples of what could be quarried and dug on a large scale from the deposits.

The limestones used were taken from several quarries, two of which the city now holds options on, from which rock can be quarried equally good and in quantities adequate to the requirements of the proposed cement plant.

The clay used in the cement mixture was dug by myself from the east end of a dry lake about five miles east of Tehachapi, alongside the S. P. Railroad and on the Cuddeback Ranch. This property includes 2500 acres, of which the lake covers nearly 300 acres. The clay is exposed in the dry bed of the lake, and 19 test borings have been made to a depth of 30 feet, the limit of the boring outfit, showing that the clay underlies the whole of the lake bed to at least that depth. The samples were free from sand, and possessed a satisfactory degree of uniformity and chemical suitability for cement material. Samples from the surface contained some organic matter and salt, and showed about 47% silica, while those taken from the lower borings contained about 55% silica.

ANALYSIS OF TEHACHAPI LAKE CLAY.

	Surface.	2 ft. deep.	8 to 12 ft. deep.	14 to 20 ft. deep.	24 ft. deep.
Silica	47.05	47.40	54.10	56.52	53.91
Alumina, ferric oxide	12.38, 5.57	19.20	23.41	24.71	20.20
Lime	8.95	6.00	5.61	5.00	6.22
Magnesia	4.74	3.26	1.04	.61	3.38
Ignition loss	17.51	17.10	14.70	11.70	15.40
Alkalies	....	.....	.....	.....	.....
Totals	96.20	92.96	98.86	98.54	99.11

The differences between the above totals and 100 are doubtless chloride of sodium.

The clay bed runs from 30 to between 40 and 50 feet thick, judging from these borings, the contours of the land, and the reports of parties who sank an artesian well nearby some years ago.

ANALYSIS OF LIMESTONE.

Silica	.451
Alumina and ferric oxide	.500
Carbonate of lime	98.250
Carbonate of magnesia	.490
Total	99.691

These materials were ground and mixed in the proportions of

Limestone	12.75 parts
Clay	4.47 parts.

The mixture, after being properly prepared, was burned in a small kiln at a temperature sufficiently high to produce a vitrified, black, sparkling clinker. The results were entirely satisfactory. The clinker did not dust, but possessed the characteristics of true Portland cement clinker.

The clinker, after cooling, was ground in a small mill to a fineness of 93%, passing a 200-mesh screen. The resultant cement possessed the color, weight and other qualities of good Portland cement.

ANALYSIS OF THE CEMENT.

Silica	21.9
Alumina and ferric oxide	13.7
Lime	61.7
Magnesia	0.486
Alkalies not determined.	
Total	97.786

This is a good analysis for Portland cement, and could be bettered by using the clays from below the surface, thus raising the silica content slightly and lowering the alumina and making a slower setting cement.

With the addition of the customary addition of plaster to act as a retarder of the initial setting time, the cement set as follows:

Initial setting time	38 minutes.
Final setting time	4 hours.

The mortar did not heat with the addition of water to the cement.

BOILING TEST FOR CONSTANCY OF VOLUME.

A pat of neat cement mortar was kept in damp air for 24 hours, then placed in an atmosphere of steam for three hours, then submerged in boiling water for three hours, at the end of which time the pat remained sound and perfect.

TENSILE STRENGTH.

In making briquettes for the determination of the tensile strength, 20% water was used for neat mortar and 10% of water in a mortar of one part of cement to three of standard testing sand. The tensile breaking strains in pounds per square inch were as follows:

	1 day.	7 days.	28 days.	5 mos.
Neat cement	362	848	870	
One cement to three sand		475	550	540

The tests have proven exceedingly satisfactory, and have demonstrated that superior Portland cement can be made with these materials. Usually better results can be obtained in a large commercial plant than in the preliminary laboratory tests.

ANALYSIS OF CUDDEBACK LIMESTONE FROM TUNNEL MARCH 13, 1907.

Silica and graphite	1.
Alumina	1.1
Carbonate of lime	97.
Carbonate of magnesia	1.36
	100.46

LOS ANGELES AQUEDUCT CEMENT PLANT WATER.

Water for the power plant at the site of the cement plant is available in abundance from artesian wells, two of which are now flowing. The water from the well at the ranch house nearby was sampled and analyzed, with the following results:

	Grains in U. S. Gallon.
Calcium sulphate	2.463
Calcium carbonate	4.789
Magnesium carbonate	2.314
Silica	1.224
Alumina	0.35

Total scale forming minerals.....11.140 grains per gallon.

This water comes from a well 125 feet deep.

The amount of scale forming materials is so small that it will be possible to use a jet or barometric condenser in the power plant instead of the surface condenser mentioned in the specifications.

The boring of this well, as well as the test borings made in prospecting the clay deposit, show that there is an artesian reservoir beneath the Cuddeback Ranch. This ranch covers 2500 acres at the east end of the valley. Nineteen borings were made in the bed of the lake, covering about 250 acres. The holes were driven to a depth of 30 feet, the limit of the augur, and with the exception of three holes at the east end, they were all in good cement making clay. It is said that the 125-foot boring for the well, made some years ago by the ranchers owning the property, indicates that this clay bed is about 40 to 50 feet thick at that point where the well was put down. Beneath the clay is found the gravel bed of the artesian reservoir. Across the east end of the ranch the borings showed a dyke which appears to form a natural dam across the bed of the valley at the lowest end, making the water rights of this ranch valuable for a townsite or manufactory.

ESTIMATED COST OF PORTLAND CEMENT PLANT.

Capacity 1000 Barrels Daily.

SUMMARY.

Cement plant machinery (except motors and freight)	$124,625
Cement plant electric motors	15,000
Freight on above	20,161
Buildings for above	40,000
Total cost, except power plant	$199,786
Power plant erected (1200 H. P. steam electric)	97,677
Building for power plant	5,000
Total	$302,463

The above summaries are based on detailed quotations of cement machinery at current prices with fair allowances for freights and erection at the proposed site of the plant.

COST OF MANUFACTURE.

Data.

Fuel oil, 75 cents per barrel.

Skilled labor, $3.00 to $3.50 per day, 8 hours.

Unskilled labor, $2.25 per day, 8 hours.

Quarried rock, 40 cents per ton.

Excavating clay, 26 cents per ton.

Hauling clay, 26 cents per ton.

Allowing 4% interest on the cost of the plant and distributing this interest charge against 360,000 barrels annual output.

On the basis of these data, experience with other plants justifies the estimate that a modern plant of 1000 barrels daily output can be operated continuously at capacity, on a conservative cost of $1.05 per barrel for cement at the works, exclusive of sacks, and of the initial cost of the cement works and of the lands containing the clay and limestone deposits. The cost of the plant and lands has not been charged against the cost of production, as it is the opinion of the engineers in charge of the aqueduct that the city can reimburse itself for its cost by selling out to some cement company on the completion of the aqueduct.

CONCLUSIONS.

The raw materials are suitable for the manufacture of superior Portland cement.

Low priced fuel oil is available for burning cement and generating power.

The proposed plant is of sufficient capacity to insure economical operation.

The location is admirably adapted to the manufacture and delivery of cement midway of the conduit line.

The plant erected will cost $300,000, exclusive of lands.

The cement can be manufactured at $1.05 per barrel.

Respectfully submitted,

E. DURYEE,
Cement Expert.

APPENDIX J.

LOS ANGELES AQUEDUCT ESTIMATES

On the Development and Sale of Hydro-Electric Power From the San Francisquito Canyon, the Same Being Three-fourths of the Total Available Power Along the Aqueduct.

A BRIEF GENERAL DESCRIPTION AND SUMMARY OF RESULTS OF EACH OF THE SEVERAL SECTIONS OF THIS REPORT.

SECTION I: **The Power Market in This Locality. Present Demand and Probable Increase.**

SECTION II: **The Valuation of Hydro-Electric Power Delivered at a Sub-Station in Los Angeles. At Wholesale Rates.**

SECTION III: **The Total Available Power in the San Francisquito Canyon Developed and Delivered for Sale at a Sub-Station in Los Angeles.**

SECTION I: "The Power Market in This Locality. Present Demand and Probable Increase:"—

It is stated that the amount of electric power used in this locality represents an average load of about 30,000 kilowatts (40,000 horsepower) and a peak load of over 50,000 kilowatts (67,000 horsepower); that little over half the peak load can be supplied by water power and that the demand will be more than doubled in five years, hence the addition at that time of 27,500 kilowatts average load and a 55,000 kilowatt peak in water power would not cause an excess, this amount being the total available power from San Francisquito Canyon and three-quarters of the total power available along the line of the aqueduct.

SECTION II: "The Valuation of Hydro-Electric Power Delivered at a Sub-Station in Los Angeles. At Wholesale Rates:"—

It is stated that this valuation is based on sale to factories, railways and distributing companies; that if the demand is not exceeded the value of hydro-electric power is fixed by the cost of steam power and hence its average selling price at wholesale is fixed at 0.8 cents per kilowatt-hour or approximately 0.6 cents per horsepower-hour on a 50 per cent average load factor basis. Load factor being the ratio of the average load for 24 hours to the peak or maximum load. The value of power will increase as the value of fuel increases.

SECTION III: "The Total Available Power in the San Francisquito Canyon Developed and Delivered for Sale at a Sub-Station in Los Angeles:"—

It is stated that the amount of this power would be 27,500 kilowatts (37,000 horsepower) average delivered load with provision for a 55,000 kilowatt (74,000 horsepower) peak load; that is the initial cost of the hydraulic work, two power houses, transmission lines and receiving sub-station would be $4,494,000.00; that the yearly operating cost, including interest and depreciation, would be $521,000.00; that the gross earnings at wholesale rates would be $1,927,000.00 and the net yearly earnings would be $1,406.000.00.

SECTION I.

THE POWER MARKET IN THIS LOCALITY. PRESENT DEMAND AND PROBABLE INCREASE.

The accompanying 24-hour load curve shows the average amount of electrical energy used in and about Los Angeles, Pasadena, Long Beach and Santa Monica at the present time, that is, for the year from June 1st, 1906, to June 1st, 1907. The average load is 23,200 K. W. and the peak or maximum load 40,900 K. W. If this were made to include Pomona, San Bernardino, Riverside, Redlands and intervening territory the average load would be not less than 30,000 K. W., that is, 40,000 horsepower, and the peak would be considerably over 50,000 K. W., 67,000 horsepower. All territory thus included is supplied from the same sources and is affected alike by supply and demand.

It should be noted that there would be about 20 per cent more electrical energy used at the present time during the hours of heavy load if it could be supplied; and further that there is in the City of Los Angeles about 25,000 H. P. in small private plants using steam and gas engines, a portion of which could be replaced by electric power.

With the addition of the large block of power that is to be delivered from the Kern River in the next few months, the average total water power delivered in the above mentioned territory will be approximately 30,000 K. W., and as there is very little provision for peak loads it remains for steam power to carry a 20,000 to 30,000 K. W. peak. At the present rate of increase the use of electric power will be more than doubled in five years. The addition, therefore, at that time of a water power arranged to deliver 27,500 K. W. average load and a 55,000 K. W. peak would not equal the increase and there would remain a considerable portion to be carried by steam or otherwise provided.

The 27,500 K. W. average delivered load and 55,000 K. W. peak referred to would be the total available power in the San Francisquito Canyon or three-fourths of the total power available along the aqueduct and that portion which would be most readily developed.

SECTION II.

THE VALUATION OF HYDRO-ELECTRIC POWER DELIVERED AT A SUB-STATION IN LOS ANGELES AT WHOLESALE RATES.

This valuation is based on the sale of power at what might be termed wholesale rates to large factories, electric railways and to distributing com

panies for lighting and smaller power. It also assumes that the water power is made reliable by the use of ample reservoirs near the power houses and by sufficient duplication of transmission lines. It should be remembered in this connection that steam power, which is the standard, is not wholly reliable.

It appears from the statement under Section I, "The Power Market in This Locality," that the total available power from the San Francisquito Canyon being an average of 27,500 K. W., 37,000 horsepower, with provision for a 55,000 K. W. peak, 74,000 horsepower, might be added to the supply of water power five years hence and still leave room for the further development of 20,000 to 30,000 kilowatts without an excess in this section of the state. So long as the supply of water power does not exceed the demand, its value, if reliable, will be little, if any, below the cost of steam power.

Interest and a sufficient allowance for depreciation to make the plant permanent being included with the other fixed charges, and fuel oil valued at 65 cents per barrel, the cost of electrical power in Los Angeles developed by steam at a 50 per cent load factor and under average operating conditions would vary from 0.65 cents per kilowatt-hour with 5000 kilowatt units to 0.8 cents with 1500 kilowatt units, and 2.0 cents with units of 100 kilowatt capacity each.

In figuring gross returns from the San Francisquito Canyon power, Section III, first a deduction of 12½ per cent is made from the figured yearly output for failure to realize on the full amount, and then 0.8 cents per kilowatt hour or approximately 0.6 cents per horsepower-hour at 50 per cent load factor is taken as the average value of power delivered, wholesale, at a sub-station in or near Los Angeles. This is equivalent to $35.00 per kilowatt per year, or to $26.00 per horsepower per year on the peak load or flat rate basis, assuming that the consumer cannot use more than 50 per cent of the available power; that is, that his average load for 24 hours is not more than 50 per cent of his peak or maximum load. To a consumer having a constant load 24 hours per day, 7 days per week, it is equivalent to $70.00 per kilowatt per year, or to $52.00 per horsepower per year.

It should be noted that as the demand for power and the price of fuel increase the future value of this power will be correspondingly greater.

SECTION III.

THE TOTAL AVAILABLE POWER IN THE SAN FRANCISQUITO CANYON DEVELOPED AND DELIVERED FOR SALE AT A SUB-STATION IN LOS ANGELES.

The estimates in this section are for the total available power developed in San Francisquito Canyon, between 40 and 45 miles from Los Angeles, and delivered in Los Angeles at a distributing switchboard in the receiving sub-station for sale at wholesale rates. Power houses include hydraulic gates at entrance to wheels and the pressure pipes are included in the extra hydraulic work given below. Three separate circuits of three phase transmission at 80,000 volts are provided for, the three circuits being necessary for reliability and regulation. The two double steel tower lines estimated on cost about the same as three single tower lines and provide space for a future fourth circuit, which will be required in developing the prospective power at other points

along the aqueduct, the San Francisquito Canyon power being but three-fourths of the total power available along the aqueduct.

The amount of power is based on 400 second-feet of water and a total net head on the wheels of 1475 feet divided into two parts of 1060 and 415 feet, respectively. Making due allowances for losses and efficiencies in developing, transmitting and transforming the power, there should be 31,500 kilowatts (42,000 horsepower) delivered in Los Angeles, but 12½ per cent has been deducted from this amount as a very conservative allowance for decrease in the average flow, due to cleaning and repairing sections of the aqueduct between reservoirs and for failure to realize on all available power, which should not be great with ample storage near the power site. The amount of power delivered in Los Angeles, therefore, is estimated at 27,500 kilowatts (37,000 horsepower) 24 hours a day every day in the year.

The capacity of machinery estimated anticipates sale of power at load factors from 40 to 60 per cent, or an average of 50 per cent, giving a total plant load factor of probably 55 per cent; by load factor is meant the ratio of the average load for 24 hours to the maximum or peak load. In planning the power houses provision should be made for the addition of one unit in each at such time as the peak load, which is the most valuable power, may make it advantageous.

The average price of power delivered as above to factories, electric railways and distributing companies is placed at 0.8 cents per kilowatt-hour on a 50 per cent load factor basis.

CONSTRUCTION COSTS.

FOR DEVELOPING THE TOTAL AVAILABLE POWER FROM THE SAN FRANCISQUITO CANYON.

Power House No. 1.

Building and foundations, including crane	$ 145,000.00
Five 7500 K. W., 3 phase, 50 cycle electric generators for continuous operation at 25% overload at 0.9 power factor	
Five water wheels of capacity to operate the generators at 25% overload. Including generator shaft, bearings, governors and gate valves	
Exciter generators and water wheels	
Switchboard wiring and small piping, material only	
Sixteen 2500 K. W., step-up transformers for Y connection and with taps for line voltages from 67,500 to 80,000 at 50 cycles. For 25% continuous overload and 0.9 power factor. Including oil.	
Total electrical and hydraulic machinery and apparatus, f. o. b. Saugus, Cal.	$ 544,000.00
Hauling and erecting all machinery and apparatus	140,000.00
Incidentals and extra expense	42,500.00
Engineering and superintendence	42,500.00
Total cost of Power House No. 1	$ 914,000.00

Power House No. 2.

Buildings and foundations, including crane	$ 110,000.00
Five 3000 K. W., 3 phase, 50 cycle electric generators for con-	

tinuous operation at 25% overload and 0.9 power factor.....	
Five water wheels of a capacity to operate the generators at 25% overload. Including generator shaft, bearings, governors and gate valves	
Exciter generators and water wheels.....	
Switchboard wiring and small piping, material only.....	
Sixteen 1000 K. W., step-up transformers for Y connection and with taps for line voltages from 67,500 to 80,000 at 50 cycles. For 25% continuous overload and 0.9 power factor. Including oil.	
Total electrical and hydraulic machinery and apparatus, f. o. b. Saugus, Cal.....$	268,000.00
Hauling and erecting all machinery and apparatus.....	85,000.00
Incidentals and extra expense.....	25,000.00
Engineering and superintendence.....	25,000.00
Total cost of Power House No. 2.....$	513,000.00

Transmission Line.

Copper for a 45-mile transmission with three circuits of three 4-0 cables each, f. o. b. Los Angeles and Saugus.....$	370,000.00
Steel towers for two separate tower lines arranged for two circuits each (providing space for one additional circuit). Average height 55 feet. Average span 650 feet.....	
4300—80,000-volt insulators	
Telephone circuits, material	
Right of way and clearing same.....	
Switching stations, material	
Total for material, excepting copper, f. o. b. Los Angeles and Saugus .....$	222,000.00
Hauling material and erecting lines and stations.....	85,000.00
Incidentals and extra expense	34,000.00
Engineering and superintendence	34,000.00
Total cost of transmission lines.....$	745,000.00

Sub-Station.

One receiving sub-station at Los Angeles. Complete, including real estate, building, step-down transformers, high and low tension switches, wiring and piping.....$	340,000.00

Reservoirs, Conduit and Pressure Pipe.

Total initial cost of extra hydraulic work incident to said power development in the San Francisquito Canyon (furnished by the hydraulic engineers) .....$	1,982,000.00

Grand Total.

Total initial cost of developing the total available power in the San Francisquito Canyon (the same being three-fourths of the power available along the entire aqueduct) and the delivery of the same at a receiving sub-station in Los Angeles.....$	4,494,000.00

YEARLY COST.

OPERATION, MAINTENANCE, INTEREST AND DEPRECIATION.
POWER HOUSES, TRANSMISSION LINES AND SUB-STATION.

Office rental, executive salaries and clerical expenses	$ 35,000.00
Chief operator, men on shifts, patrol and linemen	37,000.00
Operating supplies	9,000.00
Engineering and maintenance, that is, replacement of minor apparatus and all repairs, including labor and material, meter department and stable expense	70,000.00
General and extra expense	20,000.00
Interest and depreciation at 9%	226,000.00
Yearly cost (mechanical and electrical)	$ 397,000.00

Reservoirs, Conduit and Pressure Pipes.

Yearly cost for extra hydraulic work incident to power development as figured by the hydraulic engineers, including interest and depreciation	$ 124,000.00

Total.

Total yearly costs, including interest and depreciation, of developing the total available power in the San Francisquito Canyon and delivering the same at a receiving sub-station in Los Angeles	$ 521,000.00

YEARLY EARNINGS.

Gross earnings from 27,500 K. W. average load on the basis of 0.8 cents per K. W. hour at 50% load factor	$1,927,000.00
Net yearly earnings from said total available power in the San Francisquito Canyon, delivered at a sub-station in Los Angeles to factories, railways and distributing companies at wholesale rates	$1,406,000.00

To Mr. Wm. Mulholland,
Chief Engineer.

Respectfully submitted,

E. F. SCATTERGOOD.

Los Angeles, California, December 1st, 1906.

APPENDIX K.

REPORT OF THE AUDITOR OF THE LOS ANGELES AQUEDUCT.

March 1, 1907.

Status of Water Works Bond, 1905 Fund:		
Bonds		$1,500,000.00
Premium and interest		17,246.33
Total		$1,517,246.33
EXPENDITURES:		
General expenses, including salaries and expenses of executive offices. Clerks and attendants. Legal expenses. Printing, stationery, office rent, etc	$ 27,825.78	
Interest and taxes	10,239.87	
Real estate and water rights	996,283.91	
Water investigation	12,798.51	
Engineering	129,618.24	
Conduit	21,510.80	
Cement investigation	1,623.85	
Total	$1,199,900.96	$1,199,900.96
Balance in fund March 1, 1907		$ 317,345.37

APPENDIX L.

ASSEMBLY BILL NO. 491.

Passed the Assembly, February 12, A. D. 1907.

.....

Chief Clerk of the Assembly.

Passed the Senate, February 27, A. D. 1907.

.....

Secretary of the Senate.

This bill was received by the Governor, this ..... day of ....., A. D. 1907, at ..... o'clock .... M.

.....

Private Secretary of the Governor.

CHAPTER .....

An act amending an act entitled "An act authorizing the incurring of indebtedness by cities, town and municipal corporations for municipal improvements, and regulating the acquisition, construction or completion thereof," which became a law under constitutional provision, without governor's approval, February 25, 1901, by amending sections 2, 5, 7 and 9 thereof.

The people of the State of California, represented in senate and assembly, do enact as follows:

Section 1. That section two of an act entitled "An act authorizing the incurring of indebtedness by cities, towns and municipal corporations for municipal improvements, and regulating the acquisition, construction or completion thereof," which became a law February 25, 1901, be amended so as to read as follows:

Sec. 2. Whenever the legislative branch of any city, town or municipal corporation shall, by resolution passed by vote of two-thirds of all its members and approved by the executive of said municipality, determine that the public interests or necessity demands the acquisition, construction or completion of any municipal improvement, including bridges, water works, water rights, sewers, light or power works or plants, buildings for municipal uses, wharves, school houses, fire apparatus, and street work, or other works, property or structures necessary or convenient to carry out the objects, purposes and powers of the municipality, the cost of which will be too great to be paid out of the ordinary annual income and revenue of the municipality, it may at any

subsequent meeting of such board, by a vote of two-thirds of all its members, and also approved by the said executive, call a special election and submit to the qualified voters of said city, town or municipal corporation the proposition of incurring a debt for the purpose set forth in said resolution, and no question other than the incurring of the indebtedness for said purpose shall be submitted; **provided,** that propositions of incurring indebtedness for more than one object or purpose may be submitted at the same election. The ordinance calling such special election shall recite the objects and purposes for which the indebtedness is proposed to be incurred, the estimated cost of the proposed public improvements, the amount of the principal of the indebtedness to be incurred therefor, and the rate of interest to be paid on said indebtedness, and shall fix the date on which such special election will be held, the manner of holding such election and the voting for or against incurring such indebtedness, and in all particulars not recited in such ordinance, such election shall be held as provided by law for holding municipal elections in such municipality; **provided, however,** that if the rate of interest to be paid on such indebtedness shall not exceed four and one-half per centum per annum, payable semi-annually, the rate of interest need not be recited in such ordinance, but, in its discretion, the said legislative branch may recite in such ordinance a maximum rate of interest to be paid on such indebtedness, not exceeding six per centum per annum payable semi-annually, which rate when so recited, shall not be exceeded in the issuance of bonds for such indebtedness.

Sec. 2. That section five of the aforesaid act be amended so as to read as follows:

Section 5. All municipal bonds issued under the provisions of this act shall be payable substantially in the following manner: A part to be determined by the legislative body of the municipality, which shall be not less than one-fortieth part of the whole amount of such indebtedness, shall be paid each and every year on a day and date, and at a place within the United States, to be fixed by the legislative branch of the municipality issuing the bonds and designated in such bonds, together with the interest on all sums unpaid at such date; **provided, however,** that, in case of bonds issued for the acquisition, construction or completion of water works or light or power works or plants, or any other authorized revenue-producing public works, plant, utility or property, the legislative body of the municipality may, in its discretion determine and fix a date for the earliest maturity of the principal of such bonds not more than ten years from the date of the issue of such bonds, but, in this event, the whole amount of such indebtedness must be made payable in equal annual parts in not to exceed forty years from the time of contracting the same. The bonds shall be issued in such denominations as the legislative branch of the municipality may determine, except that no bonds shall be of a less denomination than one hundred dollars, nor of a greater denomination than one thousand dollars, and shall be payable on the day and at the place fixed in such bonds, and with interest at the rate specified in the bonds, which rate shall not be in excess of six per cent per annum and shall be payable semi-annually, and said bonds shall be signed by the executive of the municipality, and also by the treasurer thereof, and shall be countersigned by the clerk. The coupons of said bonds shall be numbered consecutively and signed by the treasurer.

In case any of such officers whose signatures or counter-signatures appear

on the bonds or coupons shall cease to be such officer before the delivery of such bonds to the purchaser, such signatures or counter-signatures shall nevertheless be valid and sufficient for all purposes the same as if they had remained in office until the delivery of the bonds.

Sec. 3. That section seven of the aforesaid act be amended so as to read as follows:

Section 7. The legislative branch of said city, town or municipality shall at the time of fixing the general tax levy, and in the manner for such general tax levy provided, levy and collect annually each year until said bonds are paid, or until there shall be a sum in the treasury of said city, town or municipality set apart for that purpose to meet all sums coming due for principal and interest on such bonds, a tax sufficient to pay the annual interest on such bonds, and also such part of the principal thereof as shall become due before the time for fixing the next general tax levy. **Provided,** however, that if the maturity of the indebtedness created by the issue of bonds be made to begin more than one year after the date of the issuance of such bonds, such tax shall be levied and collected at the time and in the manner aforesaid annually each year, sufficient to pay the interest on such indebtedness as it falls due, and also to constitute a sinking fund for the payment of the principal thereof on or before maturity. The taxes herein required to be levied and collected shall be in addition to all other taxes levied for municipal purposes, and shall be collected at the time and in the same manner as other municipal taxes are collected, and be used for no other purpose than the payment of said bonds and accruing interest.

Sec. 4. That section nine of the aforesaid act be amended so as to read as follows:

Section 9. All contracts for the construction or completion of any public work or improvement or for furnishing labor or materials therefor, as herein provided, shall be let to the lowest responsible bidder. The legislative branch of the municipality shall advertise for at least ten days in one or more newspapers published in the municipality, inviting sealed proposals for furnishing the labor and materials for the proposed work or improvement before any contract shall be made therefor. The said legislative branch shall have the right to require such bonds as they may deem best from the successful bidder to insure the faithful performance of the contract work, and shall also have the right to reject any and all bids; **provided, however,** that nothing herein contained shall be construed as prohibiting the municipality itself from constructing or completing such works or improvements, and employing the labor necessary therefor; and **provided further,** that, in cities, towns or municipalities operating under a charter, heretofore or hereafter framed under section eight of article eleven of the constitution and providing for a board of public works all the matters and things required in this section to be done and performed by the legislative branch of the municipality shall be done and performed by the board of public works of such city, town or municipality, and, in case such charter also prescribes the manner of letting and entering into contracts for the furnishing of labor, materials or supplies for the constructing or completion of public works or improvements, the contracts therefor shall be let and entered into in conformity with such charter.

Sec. 5. That nothing in this act contained shall be construed as affecting the issue or sale of bonds in pursuance of proceedings begun prior to the taking effect of this act and under the provisions of the act amended hereby.

Sec. 6. This act shall take effect immediately.

.....
Speaker of the Assembly.

.....
President of the Senate.

Approved, ..., A. D. 1907.

.....
Governor.

APPENDIX M.

SENATE BILL NO. 463.

Passed the Senate, February 5, A. D. 1907.

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Secretary of the Senate.

Passed the Assembly, March 11, A. D. 1907.

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Chief Clerk of the Assembly.

This bill was received by the Governor, this ..... day of ....., A. D. 1907, at ..... o'clock .... M.

.....

Private Secretary of the Governor.

CHAPTER .....

An act authorizing any incorporated city, town or municipal corporation to construct, equip, use, maintain and operate any works, road, railroad, tramway, power plant, telephone or telegraph line, or other necessary works or structures, for the preparation, manufacturing, handling or transporting of materials or supplies required in the construction or completion of any public work, improvement or utility, and to lease, acquire, by purchase, condemnation or otherwise, and hold and use lands and other necessary property for said purposes.

The people of the State of California, represented in senate and assembly, do enact as follows:

Section 1. Any incorporated city, town or municipal corporation in this state is hereby authorized to construct, equip, use, maintain and operate any works, road, railroad, tramway, power plant, telephone or telegraph line, or other necessary works or structures, within or without such city, town or municipal corporation, or the county wherein such city, town or municipal corporation is located, for the preparation, manufacture, handling or transporting of any materials or supplies required in the construction or completion by such city, town or municipal corporation of any public work, improvement or utility, and, for the purpose of constructing, equipping, using, maintaining or operating any such works, road, railroad, tramway, power plant, telephone or telegraph line, or other necessary works or structures, such city, town or municipal corporation is hereby authorized to lease or acquire, by purchase, condemnation or otherwise, and hold and use, any land, rights of way, water, water rights, quarry, gravel bed or other mineral deposits, or any other necessary property, within or without such city, town or municipal corporation, or the county wherein such city, town or municipal corporation is located.

Sec. 2. Nothing in this act contained shall be construed as extending or enlarging any limitation prescribed by law or municipal charter upon taxation, expenditure of public funds, or the incurring of indebtedness, by any city, town or municipal corporation.

Sec. 3. This act shall take effect immediately.

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President of the Senate.

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Speaker of the Assembly.

Approved, ..., A. D. 1907.

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Governor.